With the compliments of
John D. Runkle.

THE

MANUAL ELEMENT IN EDUCATION.

BY

JOHN D. RUNKLE, Ph.D., LL.D.,

WALKER PROFESSOR OF MATHEMATICS, INSTITUTE OF TECHNOLOGY,
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REPRINTED FROM THE FORTY-FIFTH ANNUAL REPORT OF THE SECRETARY OF THE MASSACHUSETTS BOARD OF EDUCATION.

BOSTON:
Rand, Avery, & Co., Printers to the Commonwealth.
117 Franklin Street.
1882.

THE MANUAL ELEMENT IN EDUCATION.

The Forty-first Annual Report of the Massachusetts Board of Education (1876–77) contains a paper with the above title; and I gladly comply with the wish of the honorable Board that I should prepare a second paper upon the same subject, embodying such additional experience as may have been gained in our School of Mechanic Arts and other similar schools, together with any information I may have been able to gather since the date of the first paper. My chief aim in this paper will be to furnish such details as may be of service to corporations or individuals, as hints or aids in the establishment of this kind of education.

It is hardly worth while in this connection to consider the way that this element is to find its place in our educational system. Individual opinion may for a time have some influence in directing the current of thought upon this subject; but in the end the needs of the public will control. There is already a wide-felt impression, if not conviction, that something of the kind is necessary; and this conviction is most likely to find expression at first in special mechanic art schools, in centres where the need is most felt. If these schools shall demonstrate their value, not only as training schools for fitting students to enter upon certain lines of industrial activity, but also as schools for furnishing the needed mental discipline, then it seems reasonable to suppose that this element will become more general, and just in proportion to the value in which it is held by the educated and thinking public. The methods of teaching the manual element will become better settled through a larger experience; and there will not be the present lack of teachers properly trained for this kind of education.

The revolution in the method of teaching the physical and

natural sciences now practically completed in the laboratory method, or the method of investigation as it may properly be called, is recognized, not only as best for the acquisition of the required knowledge, but also as best for the discipline it imparts; and in the same way the laboratory method of teaching the mechanic arts will gradually take its place as a practical, and at the same time a disciplinary, element in education.

It is but a few years since the idea of introducing drawing into our schools as an element of general education seemed visionary; and yet to-day it is an accomplished fact in many parts of our own country, and has been for a much longer time in many countries abroad. Drawing is now regarded by many educators as an established factor in elementary education, and destined to work its way into all classes of public schools. It was only after it was plainly seen that there is a wide distinction to be made between drawing as an art and the drawing which pertains to a specific industry of which the former can be considered only in the light of the most general preparation, that the art began to be regarded as a possible fundamental factor in a common education. Until recently but little attention has been given to the same broad distinction, which underlies all the manual processes. The old idea of "trade-schools" — that is, schools for teaching the technical details of specific industries — has become so fixed in the public mind that some writers on the general subject, and some reports of school committees, have advocated the introduction of trades into the public schools. To all who entertain this idea I earnestly commend a paper on "Technical Training in American Schools," by E. E. White, LL.D., president of Purdue University, Indiana, issued by the Bureau of Education in Washington; and, while I entirely agree with the conclusions of the paper referred to as regards the introduction of trades into our public schools, no matter of what grade, I am further convinced on general grounds, and from some opportunity of observing the working of trade or special industrial schools, in contrast with general mechanic art schools, in which drawing and other mechanic arts enter as a proper factor, that trade-schools can only be justified, if at all, in a few exceptional cases depending upon the character of those to be taught, and in some few instances upon the character of the industry, such as practical farming, horticulture, pomology, or any other industry in which the manual ele-

ment forms a very inconsiderable part of the special knowledge required, and does not involve those qualities of precision, consecutiveness, and quantitative relation, which would give it special educational value. To special schools of this class I shall hereafter refer. The arts are few, and the trades many. It is the province of a fundamental general education to deal with generals, leaving to the student the task of finding out how his general knowledge applies in special cases. In short, he learns the *technique* of his trade after he leaves the school, and enters upon his chosen specialty. But it is quite another thing to leave out of his general education all those elements which underlie all industrial pursuits, and particularly if it can be seen that the introduction of these general elements is not only educationally feasible, but desirable for the roundness and unity of the general education, and valuable, no matter what the future of those so educated may be.

Nor does it follow, as some suppose, that, because the manual element is introduced into a course of study in proportion to its value as an educational factor, therefore all who take the course must necessarily become mechanics, any more than it follows that, because all are taught the art of drawing, all must therefore follow some pursuit in which this art enters as a necessary element. But it does follow that these mechanic art shops or laboratories would be used just as laboratories for the teaching of other arts or sciences are used, — first, to teach the subject as a part of the general education, and, second, for the advanced study of those who wish to become specialists in this particular direction; that is, for general and professional education.

It is often asserted, and I think with truth, that American boys are disinclined, for various reasons, to enter upon industrial pursuits, and especially where a long shop apprenticeship is required. My experience is that the objection is oftener on the part of the parents, for the reason that the boy's general education must stop, and because, as a rule, it surrounds him with influences which often prove fatal at this critical period of his life. It is also sometimes thought that social considerations influence the boy as well as his parents. But as soon as school authorities, teachers, and the public generally show their respect for labor, by giving it consideration through educational preparation, no caste feeling will enter into the parents' or boy's choice

of a future career. He will simply consult his taste and aptitudes, and the opportunities that offer, when he is ready to go to work. The experience in our own School of Mechanic Arts for the past five years fully sustains this position. Special technical schools confessedly for the children of the poor would inevitably become caste schools; but a general technical training in some of the manual arts, including drawing, required of all during the proper period, occupying only a few hours per week, say from the age of twelve to sixteen, and before the student has sufficient mental maturity to work successfully in a science laboratory, would have an entirely opposite effect, and be at the same time an excellent preparation for industrial pursuits or for further study, no matter in what direction; for whatever subject cultivates care, close observation, exactness, patience, and method, must be a valuable training and preparation for all studies and pursuits. But few persons, I apprehend, whose education did not include drawing, have not had occasion to regret it, if on no higher ground than their inability to use the pencil or drawing-pen for the simplest purposes with any effect or satisfaction.

Before proceeding to an account of some schools in which the Russian method of mechanic art education is used, I will simply add that the Imperial Technical School of Moscow was the first to show that it is best to teach an art before attempting to apply it; that the mechanic arts can be taught to classes through a graded series of examples by the usual laboratory methods which are used in teaching the sciences. The ideas involved in the system are, first, to entirely separate the *art* from the *trade*, — the *instruction*-shops from the *construction*-shops; second, to teach each art in its own shop; third, to equip each shop with as many places and sets of tools, and thus accommodate as many pupils as the teacher can instruct at the same time; fourth, to design and graduate the series of samples to be worked out in each shop on educational grounds; and, fifth, to adopt the proper tests for proficiency and progress.

It is indeed true, that, after the arts have been learned, the next logical step in a full course is to teach their applications in constructions, either in private works, or as is done in the Moscow school. In such a school, where the curriculum covers six years, and the young engineer is needed in the service immediately upon graduation, and has not the opportunity, for any reason, to learn the details of construction in private works, then the attaching of the works to the school may be justified.

THE IMPERIAL TECHNICAL SCHOOL

IN MOSCOW, RUSSIA.

This school is entitled to the leading place in any list of schools giving mechanic art education, on account of the fact that it was the first to put this instruction upon a strictly scientific and educational basis, — first, by separating the laboratories, or instruction-shops, from the manufacturing establishment; and, second, by working out a systematic scheme of instruction in each of the underlying arts.

I. The Organization of the School.

The old school of Arts and Trades was founded in 1830; and by an imperial decree dated June 1, 1868, this school was re-organized and raised to the rank of the leading polytechnic schools of Europe. The course of instruction is six years, — three of general studies, and three of higher special studies.

The work of the second three years embraces three sections of students, mechanical engineers, technological engineers, and constructing engineers. There is a fourth section, called *praticiens*, formed exclusively of those who show exceptional aptitude for practical work, but whose theoretical studies are insufficient to pass them into the engineering sections. They take much fuller shop courses, which they complete in three years.

To be admitted to the school the applicant must present presumptive evidence of qualification, by presenting one of the following certificates: —

1. A certificate of the seventh class in a gymnasium, giving classical instruction.

2. A certificate of a completed course in a real-school of the first class.

3. A certificate of a course of study taken in a school of equal rank.

Before being definitely admitted he must pass a test examination in the following subjects: —

Russian Language. — Composition on a theme chosen by the professor.

Mathematics. — Arithmetic, algebra, elementary analysis, geometry, and plane trigonometry.

Physics. — A course of general physics.

Drawing. — Freehand and mechanical drawing.

Without the above-named certificates, the applicant must pass an examination embracing all the studies of a real-school of the first class.

The studies of the school combine theory and practice, followed in parallel courses. The extent of the scientific instruction is the same as in the leading polytechnic schools of Europe. The practical studies embrace freehand and mechanical drawing; the art of turning in wood and metals, joinery and pattern-making, fitting, locksmithing, forging, moulding, and casting. For the practical studies, special workshops have been established, furnished with all the pedagogical objects necessary for methodic instruction, which is given by special masters, who demonstrate to the pupils the fundamental principles of handwork in the mechanic arts. The school possesses in addition large manufacturing works, with all the adjuncts of a first-class establishment.

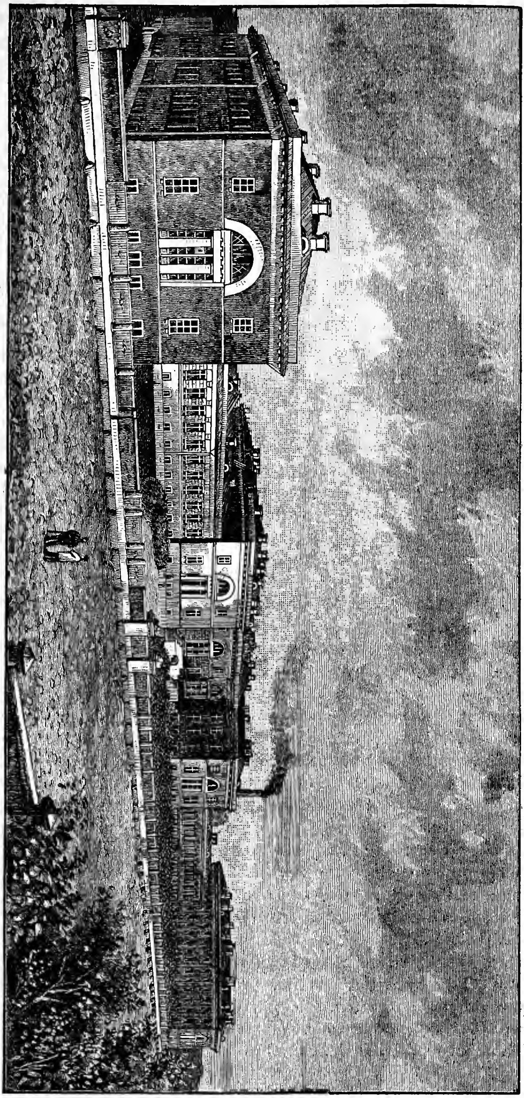
These works employ salaried workmen, and execute orders annually to the amount of a hundred and fifty to two hundred thousand francs. Still the main aim of the works is to furnish students an example of the conditions of industrial work in all its practical details.

II. The Administration of the School, its Employees and Pupils.

Serge Barsheff, honorary curator, privy councillor.

Victor Della-Vos, director, actual councillor of state.

The corps of instruction consists of professors, masters, repeaters, numbering	46
Engineer-in-chief, assistants and foremen	11
Various employees	15
	72
Under officers and soldiers in the employ of the school	84
Workmen employed in the workshops, average number	100
	184
Free boarding students	100
Boarding students, paying twelve hundred francs per year,	200
Day students paying four hundred franes per year	282
	582



THE IMPERIAL TECHNICAL SCHOOL, MOSCOW, RUSSIA.

The pedagogical council consists of the following: —

Barsheff, *Honorary Curator.*	Kossoff.
Della-Vos, *President.*	Porshesinsky.
Bashenoff, *Secretary.*	Toukovsky.
Kazaouroff.	Kolley.
Letnikoff.	Petroff.
Arkipoff.	Winogradoff.
Orloff.	Wladimirsky.
Aeschlimann.	Zeloff.
Lebedeff.	Runkle.[1]

III. The Method of Instruction in the Mechanic Arts.

The following statement is extracted from the account given by Director Della-Vos, of the exhibit of the Moscow school at Philadelphia in 1876, and again substantially the same at the Paris Exposition in 1878: —

"In 1868 the school council considered it indispensable, in order to secure the systematical teaching of elementary practical work, as well as for the more convenient supervision of the pupils while practically employed, to separate entirely the school workshops from the mechanical works in which the orders from private individuals are executed, admitting pupils to the latter only when they have perfectly acquired the principles of practical labor.

"By the separation alone of the school workshops from the mechanical works, the principal aim was, however, far from being attained. It was found necessary to work out such a method of teaching the elementary principles of mechanical art as, firstly, should demand the least possible length of time for their acquirement; secondly, should increase the facility of the supervision of the gradationary employment of the pupils; thirdly, should impart to the study itself of practical work the character of a sound, systematical acquirement of knowledge; and fourthly, and lastly, as should facilitate the demonstration of the progress of every pupil at every stated time. Everybody is well aware that the successful study of any art whatsoever, freehand or linear drawing, music, singing, painting, etc., is only attainable when the first attempts at any of them are strictly subject to the laws of gradation and successiveness, when every student adheres to a definite method or school, surmounting, little by little and by certain degrees, the difficulties to be encountered.

"All those arts, which we have just named possess a method of study which has been well worked out and defined, because, since they have long constituted a part of the education of the well-instructed classes of people, they could not but become subject to scientific analysis, could not but become the objects of investigation, with a view of defining those conditions which might render the study of them as easy and regulated as possible.

[1] Elected honorary member, Sept. 11, 1878.

"If we except the attempts made in France in the year 1867 by the celebrated and learned mechanical engineer, A. Cler, to form a collection of models for the practical study of the principal methods of forging and welding iron and steel, as well as the chief parts of joiners' work, and this with a purely demonstrative aim, — no one, as far as we are aware, has hitherto been actively engaged in the working-out of this question in its application to the study of hand labor in workshops. To the Imperial Technical School belongs the initiative in the introduction of a systematical method of teaching the arts of turning, carpentering, fitting, and forging.

"To the knowledge and experience in these specialties of the gentlemen intrusted with the management of the school workshops, and to their warm sympathy in the matter of practical education, we are indebted for the drawing-up of the programme of systematical instruction in the mechanical arts, its introduction in the year 1868 into the workshops, and also for the preparation of the necessary auxiliaries to study. In the year 1870, at the exhibition of manufactures at St. Petersburg, the school exhibited its methods of teaching mechanical arts, and from that time they have been introduced into all the technical schools of Russia.

"And now (1878) we present our system of instruction, not as a project, but as an accomplished fact, confirmed by the long experience of ten years of success in its results."

IV. The School Workshops.

(1) *Wood-Turning.* — Course I. For instruction in wood-turning, thirteen samples or models. Course II. Patterns of details and machines, thirty models.

(2) *Joinery.* — A course of twenty-five models for instruction in joinery and pattern-making.

(3) *Forging.* — Models (seventy-nine) for teaching the manipulations.

(4) *Metal-Turning.* — First course, thirty-eight samples or models. Second course, twenty-one models.

(5) *Fitting.* — Course I. Time for study, two hundred and forty hours on twenty-eight models. Course II. Time for study, two hundred and forty hours on twenty-three models. Course III. Time for study, two hundred and forty hours on twenty-four models. This shop is also fitted with benches, instruments, and apparatus for marking and lining the parts of machines to be worked.

(6) *Models for the Practical Study of the Construction of Cutting Instruments.* — I. Fourteen models of drills and countersinks increased to six times the ordinary size.

II. Eight models of the cutting parts of files increased to twenty-four times the ordinary size.

III. Ten models of screw-cutting tools increased to six times the ordinary size.

The importance of these models for teaching the theory of these tools is obvious.

It will be noticed that the course in fitting contains seventy-five models and seven hundred and twenty hours. It is found that one student cannot work the whole series in the given time, and the following system is adopted for the engineering students: Each student works one-third of the models; but he is held responsible for the remaining two-thirds by studying the work of the two who are on his right and left. When either of the three receives instruction, the other two must attend. In this way all are held responsible for the manner of working and the method of solution of each piece.

The students in the section of *praticiens*, on the other hand, must each work out the entire series.

With this account of one of the most thoroughly equipped and comprehensive schools for mechanic art and mechanical engineering education in the world, I pass to the

ROYAL MECHANIC ART SCHOOL

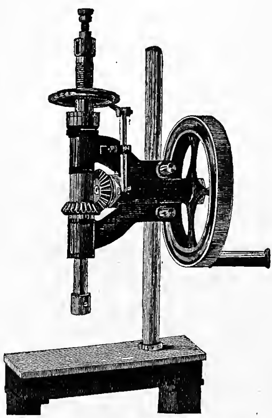
IN KOMOTAU, BOHEMIA.

This school opened Oct. 26, 1874, under the direction of Professor Theodore Reuter, who, after an inspection of the various methods of shop instruction in use in Europe, adopted that of the Moscow school, giving credit to Director Della-Vos. No manufacturing works are connected with the school. Its simple aim is to educate skilled mechanics in the best and quickest way, and with such theoretical knowledge as the mechanic needs in addition to manual skill. The front portion of the school-building, only half of which is shown in the cut, is used for the theoretical instruction, and the three portions extending at right angles in the rear contain the shops. These were at first equipped for forty-eight students; but additional facilities have been furnished from time to time to meet the increasing number of students. The minimum age for admission is fourteen years; but all ages up to twenty-six years are found in the school. The course is two years, and the student is occupied nine hours per day, — from eight to twelve M. in the

study and drawing rooms, and from one to six P.M. in the shops. The shop-work holds the first consideration, as the quality of this work is the test by which the public is to determine the value of the practical instruction. The theoretical subjects and the methods of teaching them are determined solely by the student's needs as a skilled mechanic. The following is the course of study: —

First Year's Course of Shop-Work. — 1. Carpentry and joinery, thirty hours per week for sixteen weeks. 2. Wood-turning, thirty hours per week for twelve weeks. 3. Hand-tool work in metals, thirty hours per week for twelve weeks. In this course the typical forms in locksmithery are used as models, preparatory to a course in application during the second year. The student changes his shop-work every four weeks.

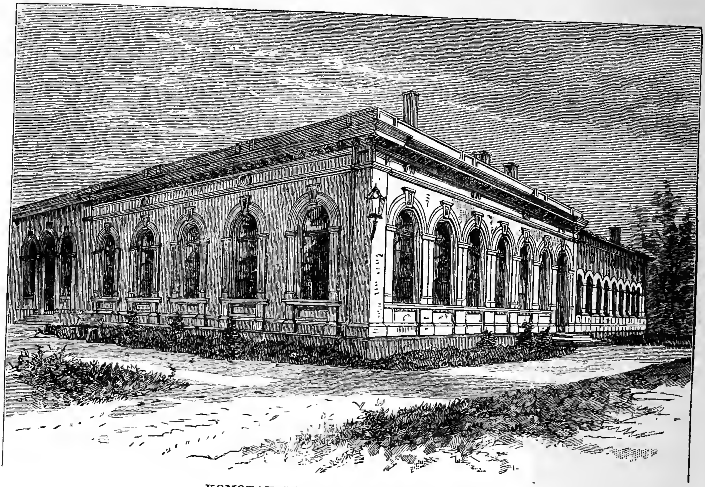
First Year's Course of Theoretical Studies. — 1. Linear drawing and the elements of projections, ten hours per week. 2. Freehand drawing, four hours per week. 3. Round-hand writing, one hour per week, winter term. 4. Arithmetic, five hours per week in winter, and two hours in summer. 5. Geometry, three hours per week in summer. 6. Physics, one hour per week. 7. Machine theory, two hours per week. 8. Simple book-keeping and business-papers. In all of these subjects only the simplest elements are taught in a plain and thorough way.



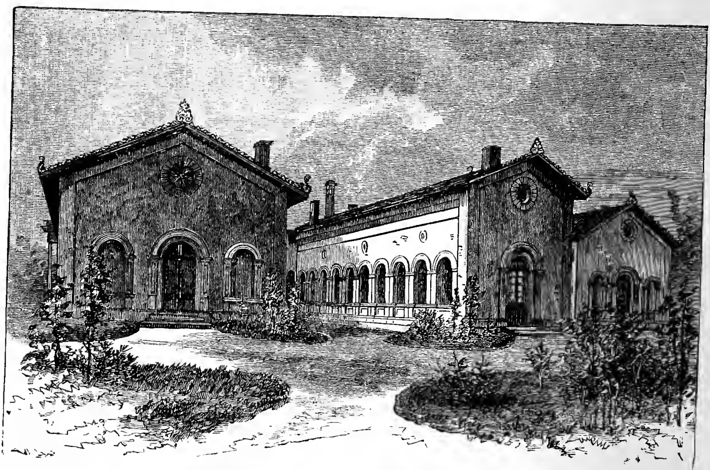
DRILLING-MACHINE.

Second Year's Course of Shop-Work. — 1. Forging, thirty hours per week for eight weeks, two hundred and forty hours. 2. Foundery-work, thirty hours per week for eight weeks. 3. Iron-turning, thirty hours per week for twelve weeks. 4. Locksmithery, an applied course of thirty hours per week of twelve weeks.

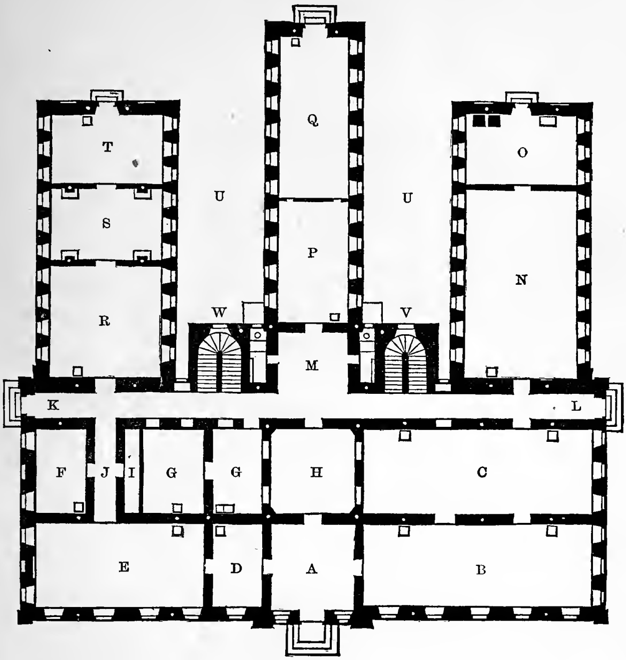
Besides the prescribed work in this course, each industrious student can make one or more complete machines. This little drilling-machine is not given as a fair specimen, but because I happened to have a photograph of it. In this extra work he



KOMOTAU SCHOOL-BUILDING — FRONT.



KOMOTAU SCHOOL-BUILDING. — REAR.



Scale 1 : 400 (5 mm = 2 M).

PLAN OF THE KOMOTAU SCHOOL-BUILDING.

A. Entrance Hall.
B. Drawing-Room.
C. Model-Room.
D. Director's Room.
E. Lecture-Room.
F. Conference and Recitation Room.
G G. Janitor's Quarters.
H. Engine-Room; Glass Roof.
I. Store-Room.
J K L. Corridors.
K. Students' Entrance.
L. Students' Exit.
M. Corridor Hall; Glass Roof.
N. Model Joinery and Pattern-Making.
O. Iron Foundery.
P. Model Wood-Turning.
Q. Iron-Turning.
R. Machine Locksmithery.
S. Forging Shop.
T. Model Locksmithery.
U U. Paved Courts.
V. Coal Magazine.
W. Iron Magazine.

For this Plan I am indebted to Director Röver.

has only the direction, suggestions, and advice of his teachers, in order to cultivate as early as possible his independence in design and execution.

Second Year's Course of Theoretical Studies. — 1. Machine-drawing, ten hours per week. 2. Freehand drawing, four hours per week. 3. Arithmetic, two hours per week. 4. Stereotomy, one hour per week. 5. Applications of arithmetic and geometry to simple machine computations, three hours per week. 6. The manipulation and manufacture of metals, one hour per week. 7. Machine theory, two hours per week. 8. Book-keeping and business-papers.

In all the shops the instruction is given through a progressive series of models, all of which each student must work; nor can he take a new one till the previous one is satisfactorily made. Any student who, through greater industry or capacity, finishes the course in advance of the class, can choose his work, with the sanction of his teacher, till the course is completed; but he cannot enter a new shop in advance of his class.

As all the materials are furnished by the school, it claims all the work. Each student has a case, with his name attached, in which his work is placed. All pieces of marked excellence are put into the collection for general and annual exhibitions in the name of the student. All the work is kept for two years, and then sold to schools and individuals for the purposes of instruction. There is a small but growing class of men abroad called *Technikers.* They do not claim to be, or rank with, engineers, but are simply skilled and well-educated mechanics; and these men are finding situations as teachers in such schools as that at Komotau. They are qualified to give instruction in both the theoretical and practical departments, and are likely to be much better teachers of shop-work than the mechanic who has only his shop experience. While there is not an excess of such men abroad, here they are difficult to find.

This school was established two years before our Mechanic Art School at the Institute of Technology, but I did not know of it till near the close of our first year. The fact that both schools had independently adopted the same method of shop instruction, drawn from the same source, made my two days' visit in Komotau of peculiar interest. At the time of my visit the school was in charge of Professor Röver, from whom I received the kindest attention, Professor Reuter having been

called to Iserlohn in Prussia, to found another school. Through the director of the Komotau school I had the pleasure of meeting Professor Hauff of the Polytechnic School of Vienna, who is the chairman of a commission having in charge the matter of intermediate industrial education in Austria. It is proposed to establish special schools in all industrial centres throughout the empire, having precisely the same aims as that at Komotau, and conducted upon the same principles and by the same methods, but varied and adapted to the industry of the particular locality, the theoretical studies conforming to the needs of the particular industry. I was informed that the aim and end of these schools is to be instruction, and only when the manufacture of certain things can be taught in an applied course more successfully than ideal or purely educational models, will it be done; the principle having already been settled that these schools were in no sense to become or to be regarded as commercial manufacturing establishments. The department of commerce has also established a practical technical school at Steyr, with workshops to teach all the processes in the working of iron and steel, — such as forging, turning, chipping, filing, boring, scraping, polishing, burnishing, soldering, tempering, annealing, gilding, silvering, nickeling, engraving, etching, coloring, staining, etc., including applications to wood, bone, horn, and ivory. In connection with the programme of the school we find the following remarks: —

"It is now beyond question, that the required education, together with the arts belonging to the several trades, can only be gained in special schools with workshops fitted up in the proper way. These workshops also make it possible for large numbers to fit themselves for the various technical trades, without having to travel the unpleasant path which leads through the years of apprenticeship, and at the same time to acquire the proper education. While the shops here relate to the manufacture of small articles in iron and steel, those at Komotau and Klagenfurt pay particular attention to the education of foremen and workmen in machine manufacturing, and those at Ferlach to gun-making.

"Just as the last-named school has proved that it is possible in a few years to revive an almost dead industry, and make workmen capable of paying taxes out of despairing mechanics, so the school at Komotau has shown the most brilliant proofs of usefulness, and the ends there gained have been acknowledged at home and abroad. One proof is, that, in spite of the hard times, all the pupils from Komotau have found occupation in different manufacturing establishments; and another, that England, a country unsurpassed in the manufactures of iron and steel, has already sent some students to the school."

SCHOOL OF MECHANIC ARTS,

INSTITUTE OF TECHNOLOGY, BOSTON, MASS.

This school was founded by a vote of the corporation of the Institute, dated Aug. 17, 1876. Since Oct. 1, 1878, it has been in charge of a committee of the faculty, Professor John M. Ordway, chairman, upon whom has devolved the main direction of the school. While adhering to the spirit and method of instruction, the aim has been to make the work in all departments as practical as possible, by selecting useful forms, if equally good, to teach the particular manipulation. The accompanying pages of cuts, showing series of samples used in each shop, are given as a general illustration, and not as the only, or even necessarily the best, series, for teaching the manipulations in each case. Every qualified teacher will naturally design his own course, and will also modify it from time to time as experience suggests. There is obviously the same freedom here as in the teaching of other subjects. The mechanic art courses are as follows: In *wood* — I. Carpentry and joinery; II. Wood-turning; III. Pattern-making. In *iron* — I. Vise-work; II. Forging; III. Foundery-work; IV. Machine-tool work.

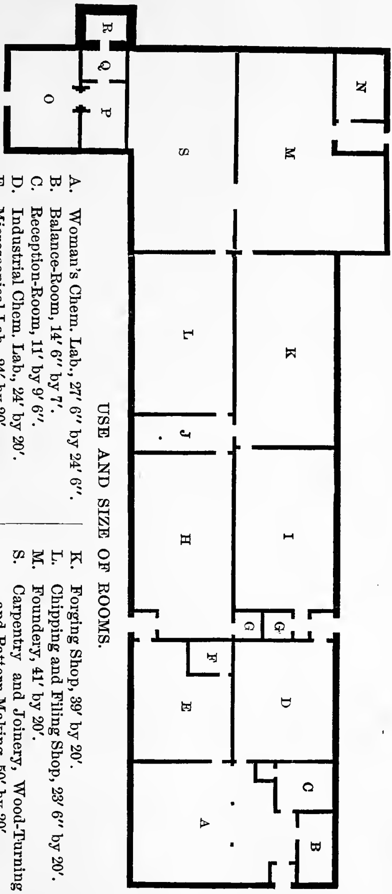
While these shops are used for the practical instruction of our students in mechanical engineering, and for such other professional students of the Institute as desire it, they are most largely used by students in the school of mechanic arts. This school, in which special prominence is given to *manual* education, has been established for those who wish to enter upon industrial pursuits, rather than to become scientific engineers. It is designed to afford such students as have completed the ordinary grammar-school course an opportunity to continue the elementary scientific and literary studies, together with mechanical and freehand drawing, while receiving theoretical and practical instruction in these various arts, including the nature and economic value of the materials with which they deal. Nine hours per week — three lessons of three hours each — of the students' time are devoted to shop-work, and the balance to drawing and other studies; only one shop course, except in the case of special shop students, being carried on at a time.

It may be well, now, briefly to indicate the steps necessary to

be taken in fitting up a shop, and in working out the course of study.

The Shop. — 1. Settle upon the tools and appliances to be

NEW TEMPORARY BUILDING FOR SHOP-WORK AND CHEMISTRY.



USE AND SIZE OF ROOMS.

A. Woman's Chem. Lab., 27′ 6″ by 24′ 6″.
B. Balance-Room, 14′ 6″ by 7′.
C. Reception-Room, 11′ by 9′ 6″.
D. Industrial Chem. Lab., 24′ by 20′.
E. Microscopical Lab., 24′ by 20′.
F. Dark Room, Spectroscope.
G G. Tool and Stock Rooms, 6′ by 6′.
H. Machine-Tool Shop, 37′ by 20′.
I. Pattern Weaving, 32′ 6″ by 20′.
J. Engine-Room, 20′ by 7′ 9″.

K. Forging Shop, 39′ by 20′.
L. Chipping and Filing Shop, 23′ 6″ by 20′.
M. Foundery, 41′ by 20′.
S. Carpentry and Joinery, Wood-Turning and Pattern-Making, 50′ by 20′.
N. Wash-Room, 13′ 6″ by 9′ 6″.
O. Organic Chem. Lab., 19′ by 14′.
P. Special Work-Room, 13′ by 9′ 6″.
Q. Store-Room, 9′ 6″ by 6′.
R. Ice-Chamber, 8′ by 5′.

used during the course. 2. Decide how many students can be taught in a section. 3. Design the fitting-up of the shop, giving each student the proper space and facilities, and so arrange

that each student, in each section, can lock up and control his own tools and instruments, which are not to be used in common.

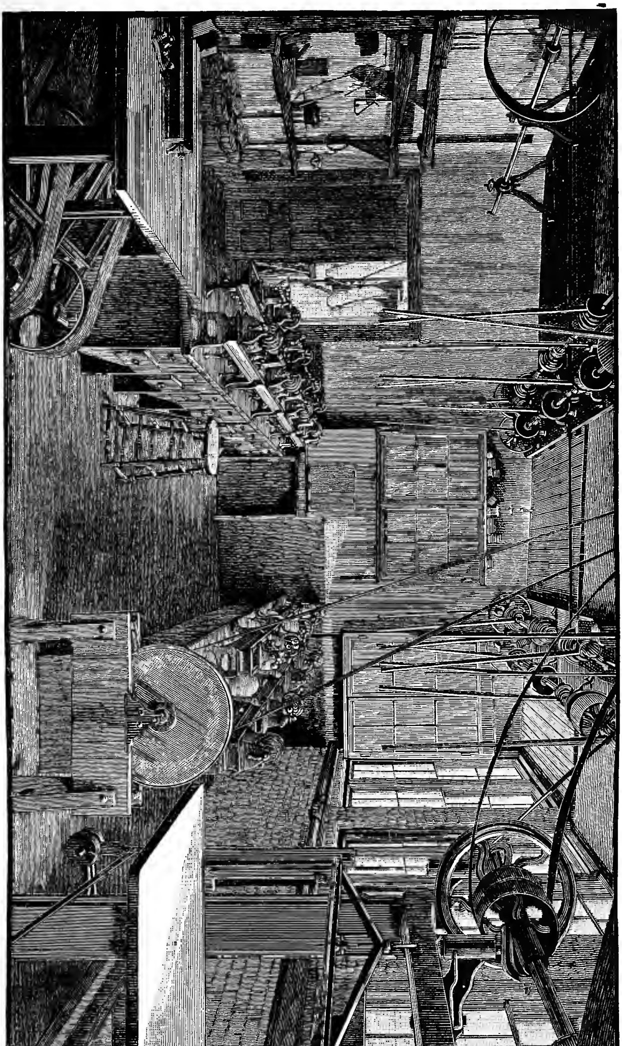
The Course of Study. — 1. Design a series of progressive lessons, especially adapted to teach the use of the set of tools and appliances pertaining to each course. 2. Let the master work each lesson, or sample, that he may settle clearly in his own mind the best method of solution, with a statement of the reasons therefor. 3. A system of inspection upon which the quality of the work can be based, and each student given his proper percentage, and which shall also be the means of educating the judgment of the student, that it may keep pace with his skill of hand to execute.

We find, then, that in this practical part of the problem there are three distinct educational steps. First, the best method of solution. Second, skill of hand to execute the work. Third, the capacity to judge of the quality of the work.

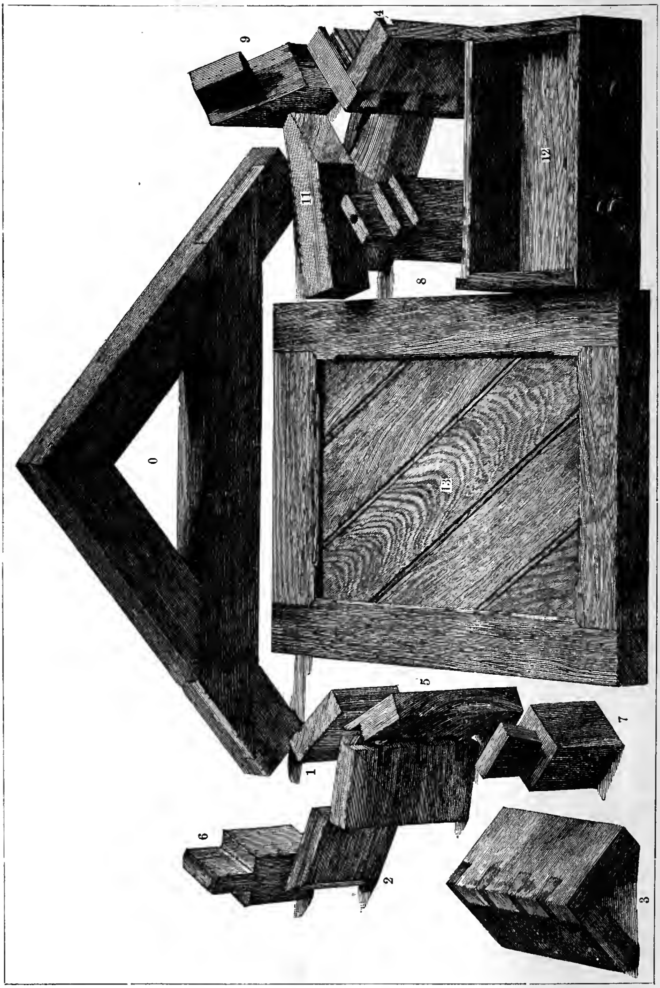
The theoretical studies are arithmetic, algebra, geometry, English, physics, and drawing. The shops are arranged for teaching sixteen in a section, except that for forging, which contains only eight forges, on account of the smallness of the room. The deficiency has been remedied as far as possible by enlarging the foundery, and using portable forges.

All our shops are entirely too small for the work we are endeavoring to do in them, and the present temporary building must soon be replaced by a larger and better adapted one, if the purposes of the school are ever fully realized.

The Carpentry, Joinery, Wood-Turning, and Pattern Shop. — This shop is 50′ by 20′, one end containing the carpentry and joinery benches, and the other the wood-turning lathes shown in the cut. The lathes are placed four on each side of two benches, and under each lathe are four drawers to hold the tools of the four sections. The carpentry and joinery benches at the other end of the room are similarly arranged. In the middle of the room, the cut shows the saws for cutting up the lumber to the dimensions needed in the courses of instruction. The first instruction in carpentry and joinery is the use of the saw and plane in working wood to given dimensions, and then a series of elements follow in order. (See cut.) No. 1, a square joint; 2, a mitre joint; 3, a dovetail joint; 4, a blind dovetail; 5, a mitre dovetail · 6, a common tenon; 7, a key tenon; 8, a tusk

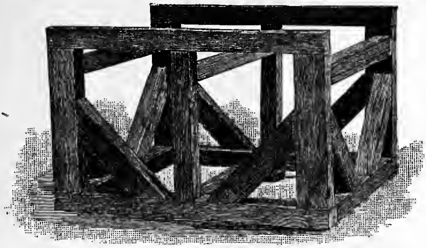


THE CARPENTRY, JOINERY, WOOD-TURNING, AND PATTERN SHOP



COURSE IN CARPENTRY AND JOINERY.

tenon; 9, a brace tenon; 10, a pair of rafters with collar-beam; 11, a truss tenon; 12, a drawer; 13, a panel. In addition to the above each student makes a small frame, to apply several of the elements of the previous lessons. A sample is given in the cut.



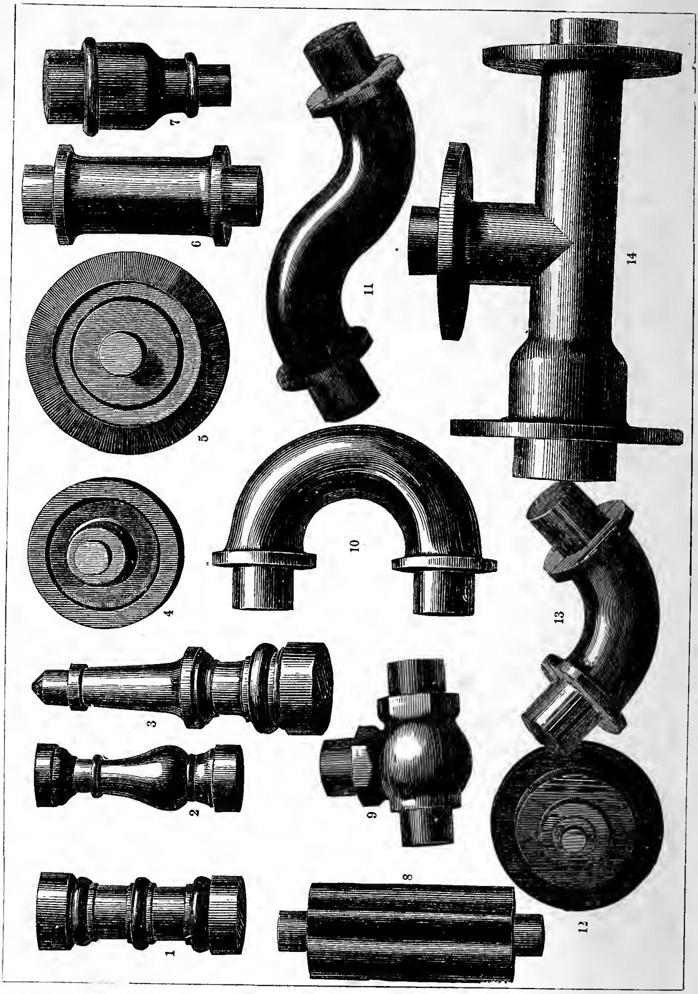
SMALL FRAME.

The instruction in turning (see cut) and circular-section pattern-making is given in the following series of models. Nos. 1, 2, and 3 represent a series of manipulations in simple turning; 4, 5, and 12, pulleys; 9, a globe-valve; 6, 7, 8, 10, 11, 13, 14, patterns for various forms of pipe. Corresponding core patterns form part of the course. Bench patterns, and bench and lathe combined, are not included for want of space.

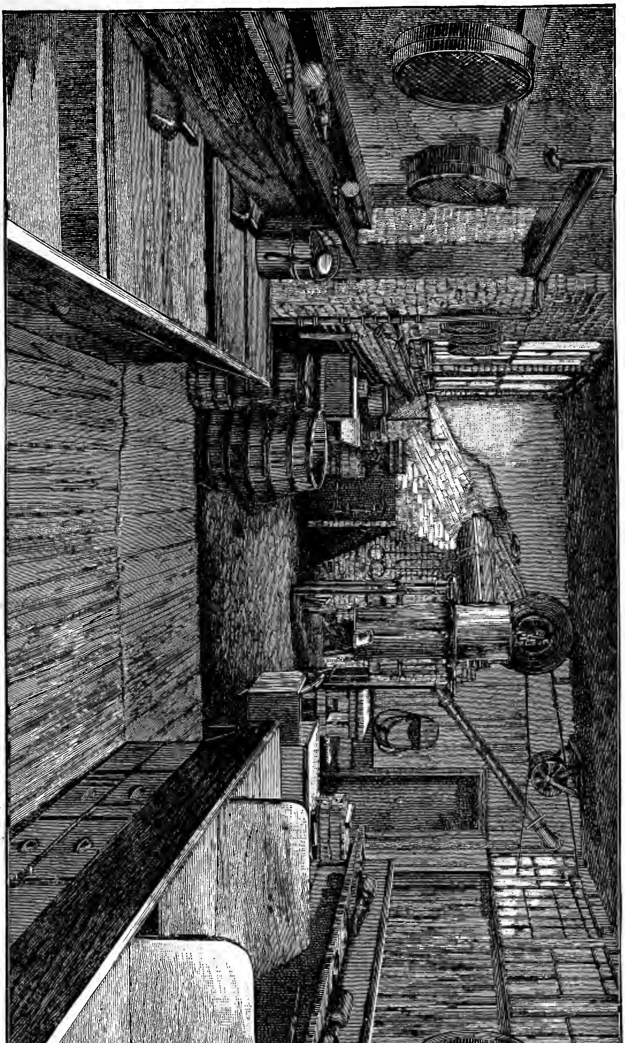
The instruction in this shop is given by Mr. George Smith, assisted by Mr. Z. Nason.

The Foundery. — The cut representing the foundery shows a part of the sixteen moulding benches, combined with troughs for holding the sand, with the cupola furnace at the other end of the room. Over the furnace is seen the Sturtevant fan, which exhausts the heat and dust from the blacksmith's shop beyond. The furnace connects with a flue which passes out of the shop, thence underground, into a chimney in the rear end of the main Institute building. The blast for the furnace is taken from the pipe shown over the door, in the rear right-hand corner of the room. An average charge of the furnace is about five hundred pounds.

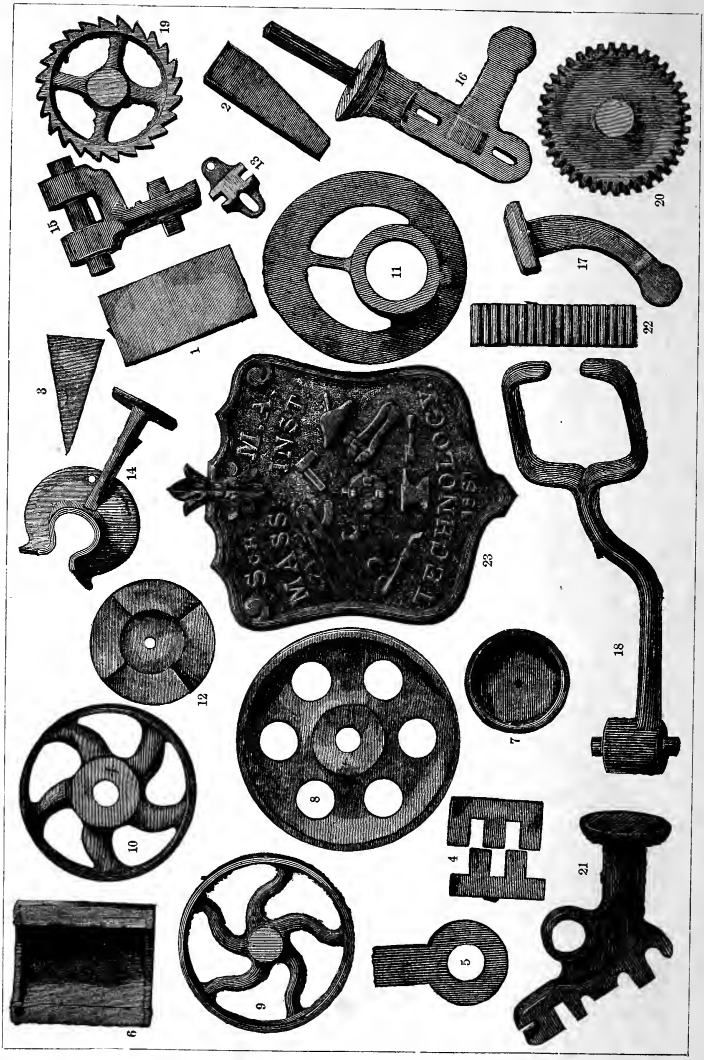
Foundery Course. — Nos. 1, 2, 3, 4, 5, are pieces used in the course of filing and chipping; 6 and 7, curved castings; 8, a sheave; 9, a pulley; 10, a pulley; 11, an eccentric; 12, a clutch; 13, 14, 15, 16, 17, 18, 21, parts of a loom; 19, 20, cog-wheels; 22, a rack; 23, a shield.



COURSE IN WOOD-TURNING AND PATTERN-MAKING.



THE FOUNDERY.



COURSE IN FOUNDERY-WORK.

The Forging Shop. — This shop is fitted with eight forges. The Sturtevant pressure blower, which furnishes the blast for the forges, is placed in the engine-room. The hoods over the forges are connected with a sixteen-inch pipe, which runs longitudinally near the ceiling of the shop, and enters a No. 4 Sturtevant exhaust blower in the foundery. This exhaust blower removes all smoke and dust, and much of the heat. This shop was planned and fitted by Mr. B. F. Sturtevant of Boston at his own expense. The school is also indebted to him for other valuable assistance.

The Machine-Tool Shop. — This shop contains sixteen engine lathes of $4\frac{1}{2}'$ bed, four speed lathes, and a Brainard milling machine. The engine lathes were made for the school by the Putnam Machine Company of Fitchburg, Mass., from new designs, and furnished at a greatly reduced cost, and have proved in all respects first-class tools. Under each lathe is a chest of drawers to hold the tools belonging to the students using it. A bench under the window holds the requisite number of vises. The shop needs a variety of additional tools, which are not furnished for want of room.

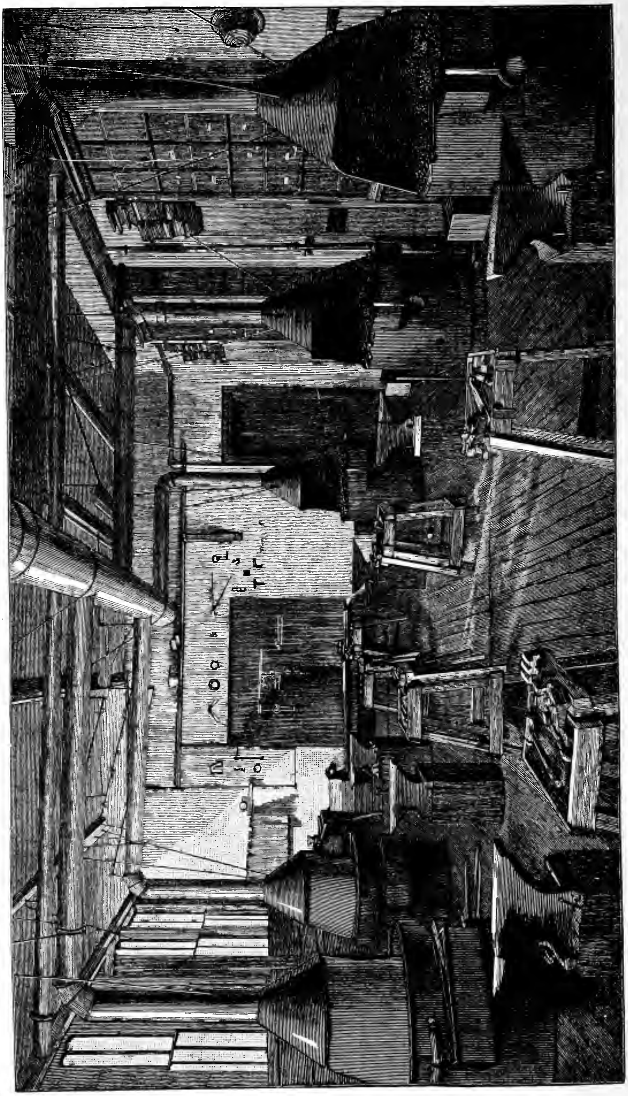
The Chipping, Filing, and Fitting Shop. — This shop contains benches with sixteen vises and other needful appliances, with a planer, grindstone, etc., for which there is no room in the machine-tool shop.

The instruction in forging, vise-work, and machine-tool work is in charge of Mr. Thomas Foley, a thorough and skilful mechanic, who has served his seven years' apprenticeship, and has had, besides, a long and varied experience in his profession. He has a clear comprehension of the problem of mechanic art education; and has, during the past five years, shown equal capacity as a teacher. He recognizes that the student should acquire something besides simple manual training in this department of education. A want of method, a want of appreciation of the ends to be gained on the part of the teacher, are both fatal to the best results. Mr. A. W. Sanborn, a graduate of the school, is Mr. Foley's assistant.

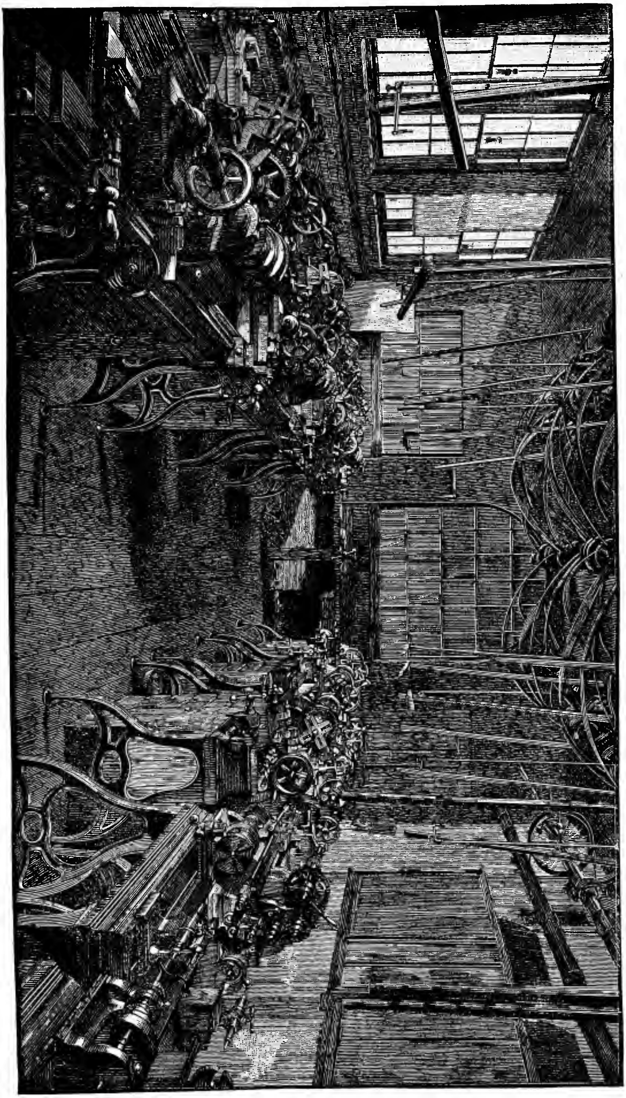
It gives me great pleasure to submit Mr. Foley's report, as follows: —

Professor J. D. Runkle.

Dear Sir, — The system of apprenticeship of the present day, as a general rule, amounts to very little for the apprentice, considering the length of



THE FORGING SHOP



MACHINE-TOOL SHOP.

time he must devote to the learning of his trade. He is kept upon such work as will most profit his employer, who thus protects himself. If the apprentice should be thoroughly taught all branches in the shortest time, he would be likely to leave as soon as he could do better, letting his employer suffer the loss of time devoted to his instruction.

Now, it appears like throwing away two or three years of one's life to attain a knowledge of any business that can be acquired in the short space of twelve or thirteen days by a proper course of instruction. The dexterity that comes from practice can be reached as quickly after the twelve days' instruction as after the two or more years spent as an apprentice under the adverse circumstances spoken of above. The plan here is to give to the student the fundamental principles in such lessons as will teach them most clearly, and give practice enough in the shortest time to acquire a knowledge of the different kinds of tools and various ways of using them. For instance, if a man can make a small article in iron, steel, or any other material, perfectly (by such methods), he can make it of larger proportions with the additional time and help required for such an undertaking. The same in degrees of heat required for fusing or welding metals: if he can do it well in a lesser degree, he can certainly do so in a greater with the additional facilities.

After nearly five years' experience in the workshops in my charge, with the valuable suggestions of the professors so much interested in the success of the school, we find the best results in the time allowed, accomplished by the method now in use in the Institute workshops; viz., three lessons per week of three hours each.

The time is just sufficient to create a vigorous interest without tiring: it also leaves a more lasting impression than by taxing the physical powers for a longer period. We have tried four hours a day, and find that a larger amount of work, and of better quality, can be produced in the three-hour lessons.

In order to give each student the proper credit, and to show him the most important points in each piece, the following method has been adopted for inspection: Take case of bending. The four shapes to the right of 4 on the cut of forgings represent bending of flat and round iron; and the points to be noted by the student are rated as follows :—

Dimensions	25
Form	70
Finish	5
	100

The most important point in this lesson is the form; the next the dimensions, and the last the finish. Through all the iron-working and other metals in each shop, the same method is carried out. Every piece is made to certain dimensions laid down upon the drawing. The object of working to dimensions is to establish the necessity of correctness in measurement, and is followed throughout the course as a very essential point. The most of the exercises convey the idea of the necessity of straight lines in drawing or lengthening iron, and graceful curves in bending.

The iron-forger's art is comprised of the following terms and movements: —

First, The management of the fire, and the degrees of heat necessary for each particular metal forgeable.

Second, Drawing *down*, or reducing the cross-section.

Third, Bending without materially changing the cross-section.

Fourth, Upsetting, or shortening the piece, and increasing its cross-section.

Fifth, Fagoting, or building up for welding, and welding the same; and welding without fagoting or building up, understood generally as welding.

Sixth, Splitting. } The terms are so well understood that they need no
Seventh, Punching. } explanation.

Eighth, Chamfering, means hammering the edges down to give the piece a light appearance.

Ninth, Annealing steel.

Tenth, Hardening and tempering steel.

Eleventh, Case-hardening iron.

Annealing brass, copper, etc., is often done by the forger, but does not really come under this head, although it is taught in this department.

The varied forms of construction are simply the adaptation of the instruction course to such variation.

Together with the main tools — the planer, lathe, milling-machine, upright drill, etc. — used in the machine course, the uses of each auxiliary tool are thoroughly explained, and sufficient practice given in short lessons to place the student on a par, so far as the general knowledge goes, with the three-years' apprentice.

The methods adopted here are as follows: A sketch of the piece is laid out to the working dimensions on the blackboard for reference during the exercise. The article is then forged in detail by the instructor before the class, calling their attention to each particular point necessary to its successful formation at the same time. There are also duplicate pieces distributed through the shop to refresh the memory and assist the eye in forming. Each student is rated according to the quantity and quality of his work, which is judged by the rules laid down for inspection.

A Brief Explanation of the Course in Iron and Steel Forging, Hardening and Tempering Steel, and Case-hardening Iron.

The first lesson comprises the building and keeping forge fires in proper condition, upon which depends in a *great* measure the success of forging. It also takes in the degrees of heat necessary for the successful working of the metals in their varied forms. The other lessons will be explained briefly but technically in order corresponding with the number in the cut to be found to the left of each piece, or in the centre of the piece when it can be so placed to advantage.

No. 2. *Cutting Cold Iron, Bevel-Forging, Drawing, Forming, and Bending.* — The bevel-forging is shown in the first form of the piece, but destroyed in taking its final form.

No. 3. *Drawing and Forming.* — Drawing is reducing the cross-section.

Forming will be better understood by the following description of the entire piece : Drawing from a round piece to form a square, then to form a portion of it octagonal, and lastly to a tapered round point. In this figure welding is introduced to show the necessity of so doing when using common iron (iron most generally used). The result of drawing such material without using a welding heat would be the separation of its parts lengthwise. In this piece the necessity of maintaining straight lines is impressed, and expected to be carried out in future lessons.

No. 4. *Bending* does not change the cross-section as much as drawing. In some cases it is hardly perceptible. This exercise consists of bending round and flat iron in a circular form. The two staples in the centre of the rings take in drawing with the bending, and are made in a useful form only because it can be done as well so without taking up extra time that might be put to a more profitable use.

Let me say here, that all through the course, whenever the principles can be introduced in a useful form without occupying more time than would be spent in a plain form, it is invariably carried out.

No. 5. *Welding, Fagot-Welding.* — This lesson is intended to show how iron can be increased in size by joining a number of pieces together by welding where it could not be done so easily or profitably by upsetting.

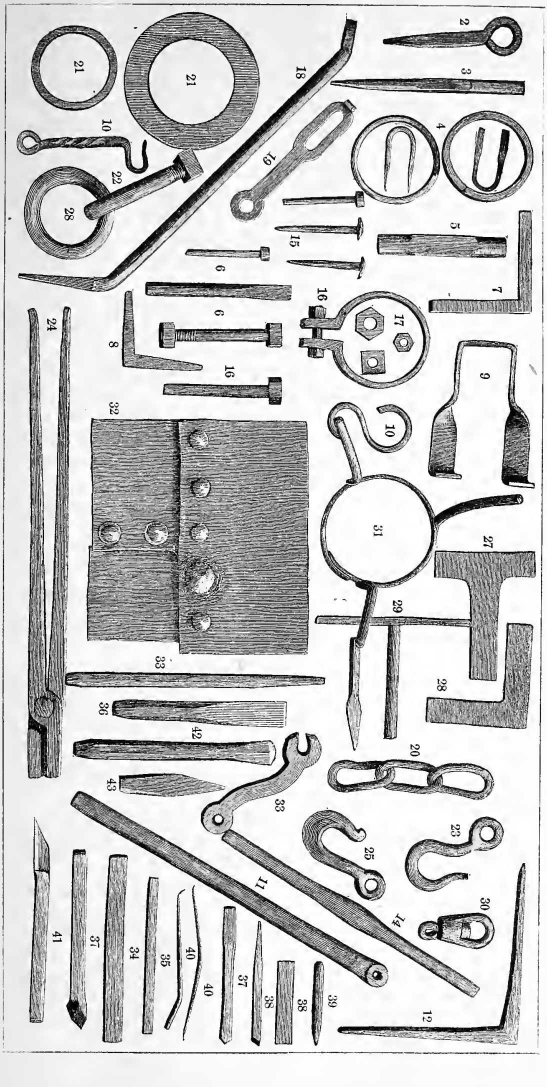
No. 6. *Upsetting, and Bolt-Making by Upsetting.* — Upsetting shortens the piece, and increases its cross-section. The first piece to the right of the figure 6 shows a piece of round iron upset at one end enough to make a square from the round of the same dimensions as the diameter of the round, and intended as preparatory to the working of the other figure to the right, — a bolt upset in the same manner to form the square head, enough being upset at the end of the piece to form the head in a heading-tool.

No. 7. *Upsetting while Bending and Forming.* — This piece, being a square made of square iron with well-defined corners inside and out, is pretty difficult to make by this method if great care is not taken in handling it. This method saves considerable time where it can be used. It is not the strongest form, and only used where neatness in appearance or nice fitting is required.

No. 8. *Upsetting before Bending and Forming.* — This piece being square only on the outside, while the inside corner is round, it is a stronger form, but for purposes differing from fig. 7; viz., a knee, angle-iron, or bracket, as it is termed. Sometimes it is intended to show the different methods of doing work similar in construction.

No. 9. *Bending and Twisting.* — Bending in this case (the piece being a floor-timber hanger) is done without upsetting, leaving it strong enough for its purpose by making the inside and outside of the turn rounding. The twisting is simply to bring the other end in position to receive the timber.

No. 10. *Drawing, Bending, and Twisting.* — The object in drawing the ends is to alter the form from square to round, and also make it lighter where the hook and eye are turned, the bending of which has already been described. The twist in the centre of the square part is intended to show how this part of ornamental work is done. The other figure No. 10, an S hook, as it is termed, is a part of this lesson, and is intended to accustom the student to the graceful curving of iron.



THE COURSE IN FORGING.

No. 11. *Upsetting, Welding, Forming, and Punching.* — A tool for making the heads of bolts, rivets, etc., known as a heading-tool.

No. 12. *Upsetting, Drawing, Bending, Chamfering, and Punching.* — This piece, a bracket, combines the movements designated by the heading of the lesson. We find, in such combinations throughout the course, that it keeps the student well up in memory (and practice with the hands) of the past lessons.

No. 13. *Bending, Drawing, Welding, and Forming.* — In this combination the ring is made in three pieces, involving the above movements. The object of this piece is to show how large bands of this form can be made with economy of time and material.

No. 14. *Butt or Jump Weld.* — This piece is intended to show how a swell can be made in the centre, or any other point, of the bar; also to show the treatment such welds should receive after welding, in order to preserve the strength of the weld.

No. 15. *Drawing and Upsetting in Heading-Tool.* — Rivets and clout or dog nails are what has been made in the tool No. 11. The main feature in the lesson is making the required shaped head, and keeping the body of the piece in the centre of the head.

No. 16. *Upsetting and Drawing.* — One of the hexagonal-headed bolts was made by upsetting the bolt to form the head. The other, a small one, No. 16, will be found forming a part of No. 13, and was made by drawing the body of the piece, and forming the head out of the stock from which the body was drawn. The object of this lesson is to give the necessary practice required to form the sides of the head uniform.

No. 17. *Punching. Making Square and Hexagonal Nuts.* — In this lesson the different methods of making nuts by the use of the hammer alone, and by the use of the hexagonal tool, are carried out.

No. 18. *Upsetting, Punching, Welding, and Fitting.* — This piece, a solid eye-stay or brace, as it is termed, besides the combination used in former lessons, takes in fitting or setting the piece to a given angle as a support. Countersinking for screw-heads is also included.

No. 19. *Punching, Splitting, Forming, and Welding.* — This form of hasp is only introduced to give practice in splitting, along with the other processes.

No. 20. *Bending, Scarfing, and Welding Round Iron* — The links of chain that form the lesson introduce a different scarf for welding from the ordinary one of straight round iron. The twisting of the chain is also brought in here.

No. 21. *Bending and Welding Flat and Edgewise.* — The two pieces numbered as above are close together on the plate, and need but little explanation on account of the correctness of their delineation, the difference in the shape of scarfing before welding being the only excuse for making this remark as the point of the lesson.

No. 22. *Drawing, Bending, and Welding.* — A piece well known as an eye-bolt or ring-bolt, the manner of shaping and scarfing being the particular points in the piece. A nut at the end of the bolt, with a screw cut upon it, will be described at the close of the lessons. This figure will be found upon the cut in conjunction with No. 28, a ring welded after being passed through the eye making the piece complete.

No. 23. *Drawing, Welding, and Forming.* — The main point in this piece is the formation of the eye by turning and welding it in such a manner as to make it appear as a solid piece of metal punched and worked out. It is only intended, as a general thing, for work to be finished. The figure itself is intended for a rope-hook.

No. 24. *Drawing, Punching, Upsetting, Welding, and Riveting.* — In introducing this piece it is considered necessary that the student should be able to construct one of the most essential tools used in the art of forging; viz., a blacksmith's tongs; and, as it combines nearly all that has been gone through in former lessons, it naturally brings to mind what might be lost in a measure without such a combination of them.

No. 25. *Punching, Drawing, and Forming.* — The piece here represented differs only in the formation of the eye (by punching) and the hook part (by flattening, to give it greater strength) from No. 23. This hook is used generally as a chain-hook.

No. 26. *Scarf-Welding, Flat Iron. (Common Iron.)* — This piece, an L or right-angled weld, has to be scarfed in a different manner from any thing before in this course, and on this account it is brought in here, with the additional point, squaring the piece.

No. 27. *Scarf-Welding, Flat Iron. (Norway Iron.)* — A different form of scarf from last number. It is what is termed a T weld, and the peculiarity of the scarf is one of the most essential points; another, the forming of the piece before taking a second welding-heat, in order to give the piece the appearance of being solid. In this lesson we use the best of iron, and in the last poor iron, or what is in common use: by this means the student is brought to see the difference of treatment in welding the two qualities of iron.

No. 28. *Bending and Welding.* — The figure with the number above attached in the cut is a ring welded after being passed through the eye of the ring-bolt No. 22, making the two as one complete piece, a ring-bolt. The most particular feature in this piece is the forming of the scarf in such a manner as to make the welding of it easy.

No. 29. *Jump Weld, Round upon Flat.* — The round and flat iron welded in this way clearly shows by their scarfing how any other shaped iron can be welded together in the same way. In this piece the scarfs differ from the former scarfs materially. The varied uses to which the piece can be put can easily be perceived.

No 30. *Drawing, Forming, Punching, and Welding.* — This combination brings into play some difficult movements in order to produce a sound swivel, as the piece is termed. One of the pieces forged in lesson No. 15 forms the revolving portion of the piece when complete.

No. 31. *Bending and Riveting.* — The tripod with this number in the centre, although it takes in bending, is intended more particularly to show how riveting cold iron is done. By the addition of bending, it leaves the piece in a useful form.

No. 32. *Scarfing, Riveting, and Calking Boiler-Plate.* — The object of this lesson is to show how iron plates can be put together, and made steam-tight. Some of the rivets are riveted with the use of a heading-tool, and some are riveted in the ordinary way with hammers. The piece is afterwards calked to make it tight, with a tool termed a calking-tool.

No. 33. *Steel-Forging.* — Cast steel of different grades and different manufactures is introduced throughout the course of steel-forging. Spring steel, too, is taken in, and the many ways of determining the quality and method of treating it in its various changes.

The first piece, No. 33, is an S wrench, — to be finished in the filing course, where the reasons for so doing are explained. In forging this piece the degree of heat necessary for the successful working of steel is practically illustrated by the instructor, and consequently very few failures occur. Annealing, or softening, hardening, and tempering, comes in at the close of the steel lessons.

No. 34. *Welding Steel and Iron together, and Steel and Steel together.* — A flat piece of iron and steel are welded together, after the very essential preparation in scarfing, and then the steel and steel are welded, making the piece complete in six inches in length.

No. 35. *Forked or Split Weld.* (*Steel and Iron.*) — A form of welding in more general use than any other; and, wherever it can be used with convenience, insures economy in time and strength in the piece, being supported on each side by the iron, making, as a general thing, a better weld or more substantial piece.

No. 36. *Tapers and Bevels.* (*Cast Steel.*) — A blacksmith's punch and cold-chisel, numbered as above, upon the cut, is intended to carry out the heading of the lesson, making true tapers and bevels throughout.

No. 37. *Drawing and Forming.* — The first one, a right-hand, diamond-pointed lathe-tool (to be used in the machine-shop). The correctness of its shape and temper prompts the student to have it as near perfect as possible, on account of having to use the same tool in his future work.

The second, a ratchet drill (its shape and temper differing considerably from a lathe or vertical drill) is clearly explained, while in comparison the other forms are shown at the same time.

No. 38. *Drawing Tapers and Bevels.* — The first piece of this number, a graver or diamond-pointed hand-tool (to be used in the machine-shop course), is plain in its appearance; but the main point is the tempering of the piece.

The second, a matching-tool, a wood-working revolving tool. The object in introducing this plain form is to show in the last lesson (tempering) how such wood-working tools as moulding, planing, and matching tools should be tempered to insure comparative success in working wood.

No. 39. *Tapers and Bevels.* (*Drawing Cast Steel.*) — The first piece, No. 39, is a cape-chisel, used for cutting grooves in iron or any other metal. It is formed from a square to an octagonal form, to give practice in changing steel, as well as iron, into different shapes; but the main point is the formation of the chisel part of the piece. The second piece, No. 39, is a centre-punch, a tool in use among nearly all metal-workers.

No. 40. *Drawing and Shaping.* — The first piece, No. 40, is cast-steel offset spring. The second, a half-elliptic spring, made of spring steel. The object in introducing the different kinds of steel for this purpose is to show the difference in methods of tempering each, one being hardened in water, the other in oil.

No. 41. *Drawing and Shaping.* (*Cast Steel.*) — A right-hand side tool, to be used in course in machine-shops.

No. 42. *Drawing and Bevelling.* (*Cast Steel.*) — A stone-drill, the correct form and temper being the main features in the piece.

No. 43. *Drawing, Punching, and Tapering.* (*Cast Steel.*) — A riveting hammer. The idea of bringing as many tools used in working iron into the course as possible has been carried out as far as consistent with the time allowed for giving a general knowledge of the manipulations. At the close of the course, hardening and tempering are explained. A set of the pieces is hardened and tempered before the class. Then each student tempers his pieces, and they are then tested to see if they are fit to do the work intended for them.

An excuse must be made for the incorrectness in the shape of some of the pieces, as they are the forms made by the students; but I think an impartial judge would allow that they will compare favorably with work done daily by blacksmiths with as many years' experience as the student has had days.

The use of stocks and dies for screw-cutting, and drills, countersinks, etc., is taught also.

Description of Course in Vise-Work.

A given time is allowed for the completion of each piece. If a student completes his work within the given time, he is allowed to take the next piece, or make any article he chooses, to use up the time allowed for the lesson. Each lesson in filing is varied in such a manner as to insure the introduction of the different shaped files, and their application to the varied forms.

The machine and filing course, occupying the same plate without regard to their precise order, must necessarily be followed by number, without regard to position.

The pieces intended for filing are planed in order to remove the rough scale so detrimental to files. The pieces, however, are planed out of true, in order to have the student bring the piece to perfection by the use of the file.

Lesson 1. No. 17. *Filing to Line.* — A plain block of cast iron, a certain amount of which is filed off true to given lines struck off by the planer. In this piece the student is taught how to regulate the movement of the file in order to produce a true surface, with the assistance of a straight edge.

Lesson 2. No. 17. — The side and end are filed square with first true surface, a steel square being used to assist in its formation.

Lesson 3. No. 18. *Cast Iron.* — On one side of piece No. 17 a half-hexagonal form is laid out and lined in the vise by the student, and finally finished in that form with the file. In this case the one block is made to do service in the three lessons, saving time and material.

Lesson 4. No. 19. *Cast Iron.* — The object of this piece is to show the different shaped files used in making rack-teeth. This lesson shows how any sharp-bottomed piece can be formed, aside from the rack.

Lesson 5. No 20. *Dovetailing.* (*Wrought Iron.*) — This piece introduces drilling, sawing, chipping, and filing. The difference and method of working the two materials, cast and wrought iron, are brought out in this lesson, comparing the method of finishing with the last lesson.

Lesson 6. No. 21. — A cast-steel wrench, made in forging course, intro-

duces inside and outside curve-filing, square hole filed from a round one, also draw-filing.

LESSON 7. No. 22. *Parallel Fitting Tongues and Grooves.* — An iron casting, lined out by the student and fitted in the form represented; the perfection of which is a good indication of the progress made after the few lessons already taken.

LESSON 8. No. 23. *Freehand Filing, with use of Hand-Vise.* — A round cast-steel piece reduced in diameter its entire length, and filed at one end to a tapering point; the main feature in the piece being a true taper, and having the point in the centre of the body.

LESSON 9. No. 25. — Comes under the same heading as last number. This piece is reduced the whole length in diameter; then a given portion is reduced still more, in order to form a shoulder on the piece, making what is termed a screw-blank (Material, cast steel.)

LESSON 10. No. 24. — Classed the same as last two numbers. Is a piece of cast steel (round) filed into the shape of an acorn, from memory, by the student.

LESSON 11. No. 26. *Ring-Work. Freehand Filing.* (*Cast Iron.*) — The blank to the right of the number shows the piece before filing; the one to the left is the finished form. The first form is square around the ring, and finally finished into a round form.

LESSON 12. No. 27. *Chipping Bevels.* (*Cast Iron.*) — The first form is a plain block, lined upon the planer the distance from the edge intended for the bevel. This piece introduces the use of the flat cold-chisel.

LESSONS 13, 14, and 15. No. 28. — Upon this one block (wrought iron) we introduce key-way or key-seat chipping, half-round chamfering, convex and concave chipping, involving the use of cape-chisels, half-round and flat chisels, and shows the difference in treatment of the two materials; viz., cast and wrought iron. By making one block serve for the three lessons, it saves time, stock, and room.

LESSON 16. No. 29. *Drilling, Chipping, and Filing to Line.* — A planed flat piece of cast iron upon which is laid out or lined an oval shape. All that can be drilled out of it is next done, and the stock remaining within the lines is then chipped and filed to the line.

LESSON 17. No. 30. *Ward-Filing and Key-Fitting.* — A key-blank is taken for this purpose, and filed to given dimensions, and afterwards fitted to the lock.

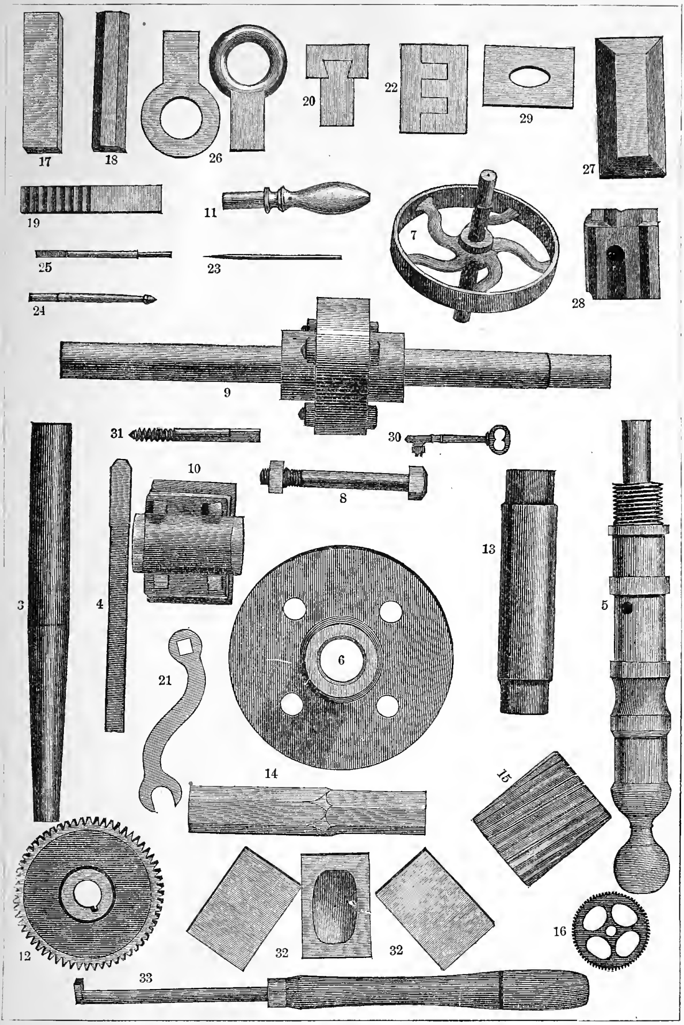
LESSON 18. No. 31. *Screw-Filing.* — The object of this lesson is to show how a screw can be cut with a file, when the lathe or stocks and dies are not available.

LESSON 19. No. 32. *Scraping.* — The three pieces together with the scraping-tool below them, No. 33, show what is necessary to produce a true surface by this method.

No. 33 is a very fine piece of forging and tempering, forged and finished in the filing course, and not set down in the forging course, by mistake.

DESCRIPTION OF THE COURSE IN MACHINE-TOOL WORK.

LESSON 1. A screw-cutting or engine lathe is taken to pieces, and each particular piece, used in the construction of the tool, is described in order



COURSES IN MACHINE-SHOP.

that the class may be made familiar with it before using it, and by this means expensive machinery may be saved from unnecessary damage.

LESSON 2. *Centring, Squaring Ends, Roughing and Finishing Chip. (Cast Iron.)* — The piece of cylindrical form is first trued up, afterward centre-drilled, countersunk, squared up on the ends, and then a roughing and smoothing chip.

LESSON 3. *Taper Turning. (Cast Iron.)* — The first piece numbered on the cut is turned two different tapers. The stock of the last lesson is used in this, to save the time centring and squaring up : consequently the first piece, Lesson 2, does not appear upon the cut.

No. 4. *Turning Flat Pieces upon the Edges.* — This piece, a flat chuck-drill, intended for use on piece No. 5, shows how flat pieces can be turned on the sides and chamfered on the ends, and also made into a tool.

A rough wrought-iron piece of cylindrical form centred, etc., as in the case of the preceding piece, but wholly differing in the manner of working it. In this lesson we introduce the tools required for turning and boring wrought iron (differing considerably in form from the tools used in working cast iron); namely, the diamond-pointed tool, side tools, right and left twist drill, flat chuck-drill (with its rest), taper reamer, screw-cutting tool, round-nosed or spoon-shaped tool, parting or cutting-off tool.

The introduction of various auxiliary tools, such as the centre rest, forked centre, square centre, etc., gives a great amount of practice in wrought iron working in this one piece. In this piece may be found centre rest chucking, the different forms of bearings in use, taper fitting, outside screw cutting, drilling through the piece at the end of the taper fit, convex and concave turning with engine and hand or speed lathes, and use of tools accompanying the last-named lathe.

No. 6. *Chucking, Inside Screw Cutting, etc.* — This piece is fitted to the screw cut upon the last piece, showing the uses of the boring-tool, recessing or inside cutting-off tool, on the outside of the piece. The tools described in the former lessons are brought in play, slightly altered to suit the material (cast iron), also the method of facing up the plate of iron in order to make it true, and showing how to lay out and drill holes at equal distances from one another upon a given circle.

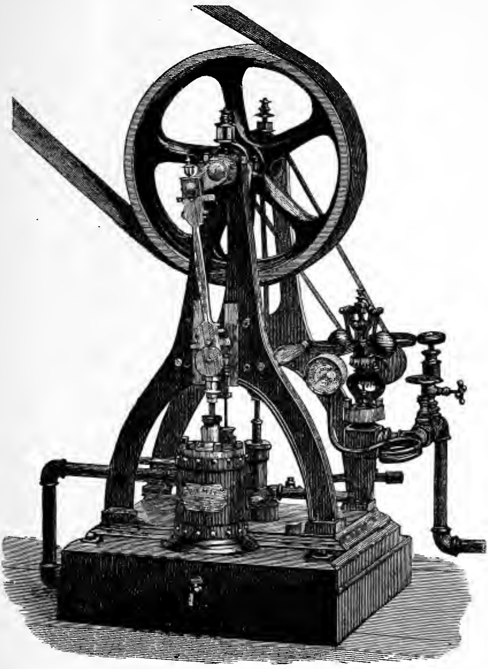
No. 7. *Pulley Chucking, Turning, Reaming, etc.* — A driving fit, crown turning, squaring, and filing with speed, are introduced in this piece. Accompanying it, and driven through the centre of the piece, is an arbor upon which the pulley is turned. This arbor, like the one No. 13, is made of steel annealed first, and tempered when the ends are finished; finally the body is turned to fit the pulley, and by this method insuring the truthfulness of the arbor for a longer period on account of the ends being tempered.

No. 8. *Bolt-Turning, and Screw-Cutting outside.* — This piece, made in the forging course, is used here to show how this form can be finished with more accuracy than by the methods in general use, such as stocks and dies, screw-cutting machines, bolt-cutters, etc. It is only intended for true fitting, too expensive a method for rough purposes, but invaluable for service in first-class machinery. The tapping of the nuts by the machine-tap, and finishing of the nuts, are also brought in in this lesson.

No. 9. Shows the turning and fitting of shafting couplings, or any other

piece where a driving or running fit is required. Key-seat cutting, splining, key-fitting, etc., with the use of planer, hand-splining tools, etc., for this purpose.

No. 10 introduces the use of the planer in fitting the two parts of the box and bottom of the piece, termed a pedestal or pillar block. The lesson also shows how the bolt-holes should be laid out and drilled in order that the bolts should have a proper bearing in connecting the cap and bottom of the box, so as to make a substantial bearing for the introduction of the



STEAM-ENGINE CONSTRUCTED BY A. W. SANBORN.

main feature of the lesson; viz., a boring-bar, a tool used for boring engine-cylinders, etc. In this piece although upon a small scale, is carried out each particular point required on a larger scale.

No. 11. *Brass-Turning.* — In this single piece the uses of the various tools for outside turning, at the same time the reverse tools for inside turning, are explained. The main point in the lesson is to show the great difference in the shape of the tools required for use upon the softer metals.

Nos. 12, 13, 14, 15, and 16 are pieces worked out in the Universal Milling Machine.

The uses of the index-head, gear-cutting, straight and bevelled, the many-sided forms that can be cut with the help of the index-head, spiral cutting, use of vise attached to the machine, etc., — all the movements necessary to accomplish any of the pieces, — are executed by the students before actual work is commenced. By this means they become familiar with the working of it, and consequently have more confidence in themselves, and are less liable to damage the machine or tools.

Nos. 12 and 16 represent gear-cutting.

No. 13. — An arbor used in connection with No. 15 in spiral cutting.

No. 14. — A piece of plain milling, six sided on one end and seven upon the other.

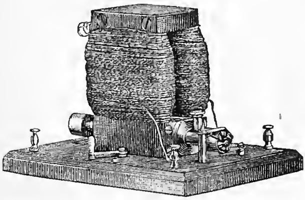
No. 15. — A piece of spiral cutting.

Many other pieces are drawn in, such as fluting reamers, taps, etc.

After acquiring a knowledge of the use of the tools by this method, the student takes in hand a piece or machine of his own design, — for instance, a lathe, steam-engine, etc., — thus showing how easily this method can be applied to construction.

With this closes the present course of instruction in use in the machine-shop.

It has been supposed that these elementary shop courses could not be so conducted as to give the students much notion of any specific applications in construction; but any one who will study Mr. Foley's report carefully will, I think, come to a different conclusion. As illustrations I insert cuts of work done by two pupils, whose whole knowledge and experience were gained in the shops during their two years' course. But the time devoted to shop instruction is too short to enable all students to show in a like way, and to the same extent, what they can do in application. If the course were three years, each student could devote the time allotted to shop instruction during the third year, in working out one or more of his own designs, which would be a proper termination of his shop studies in connection with the school.



ELECTRIC MACHINE MADE BY H. M. POPE.

MECHANIC ART INSTRUCTION

IN THE STATE COLLEGE, ORONO, MAINE.

President Fernald says, "This instruction was introduced into our Department of Mechanics four years ago, and has been prosecuted with constant interest and success. We have established, in shops of a temporary character, two courses, — vise-work and forging, carrying out the system much as is done in the Massachusetts Institute of Technology. Pupils take to the work with zeal, and their progress in it has been in the highest degree satisfactory. The number of lessons in vise-work is forty-two, of three hours each, five per week. The course includes twenty-three different pieces. Sometimes the class has been divided, each section working on alternate days. The course in forging includes twenty-eight pieces, with lessons in length the same as in vise-work, and about the same number. At the earliest date possible we design to extend the system in our college. We do not regard the work as interfering with other studies, but as constituting a part of a carefully devised scheme, or course of study, in which it is entitled to the time required. It is scarcely possible that manual skill can be acquired in accordance with a definite and progressive plan of work, in which the principles and processes are made prominent, without at the same time giving a certain amount of intellectual discipline, an amount by no means unimportant."

THE DEPARTMENT OF MECHANIC ARTS,

PURDUE UNIVERSITY, LAFAYETTE, IND.

In 1879 the collegiate department of the university was re-organized, and made to embrace three courses, — the scientific, the agricultural, and the mechanical. An "experimental station" was attached to the agricultural course, and workshops to the mechanical course. Mr. William F. M. Goss, a graduate of the School of Mechanic Arts of the Massachusetts Institute of Technology, was appointed instructor in mechanics. Mr. Goss has furnished me with a plan of the shops, and a very full account of the equipment and method of instruction

pursued in them, from which I have made the following condensed statement: —

"Applicants for admission to the mechanical course must be over sixteen years of age, and pass satisfactory examinations in the common branches, elementary algebra including quadratic equations, history of the United States, physical geography, and physiology. Graduates of high schools, who hold a certificate of the State Board of Education, are admitted without examination.

Mechanical Course.

N.B. — The required branches are printed in SMALL CAPS.; the elective branches in *Italics*.

FRESHMAN YEAR.

	SHOP PRACTICE.			
1st Term.	WOOD-WORK.	CARPENTRY.	GEOMETRY.	INDUSTRIAL DRAWING.
2d Term.	PATTERN-MAKING.	PATTERN CONSTRUCTION. CASTING AND FOUNDING.	GEOMETRY.	INDUSTRIAL DRAWING.
3d Term.	VISE-WORK.	MACHINE-DRAWING.	GEOMETRY, 6 w. ALGEBRA.	INDUSTRIAL DRAWING.

ENGLISH COMPOSITION, one lesson a week; *Military Tactics*, three exercises a week.

SOPHOMORE YEAR.

	SHOP PRACTICE.			
1st Term.	FORGING.	MACHINE-DRAWING.	HIGHER ALGEBRA.	ANCIENT HISTORY.
2d Term.	MACHINE-WORK.	MACHINE-DRAWING.	TRIGONOMETRY.	PHYSICS.
3d Term.	MACHINE-WORK.	MILL-WORK; MACHINERY.	SURVEYING.	PHYSICS.

LITERARY EXERCISES, one a week; *Military Tactics*, three exercises a week.

The shop practice includes two hours of actual work in the shop daily, five days each week. Students who wish to take a course in Mechanical or Civil Engineering will be admitted to the School on the completion of the above course. The School of Engineering will be opened in September, 1882.

Explanation of the Plan. — Room *A* is the main shop for wood and iron work; *B* and *C* are the forging shops; *D* is a storage-room; *E* is used by the chemical department. No. 1, machine lathe, 6-foot bed; 2, machine lathe, 3-foot bed; 3, wood lathe, 9-foot bed; 4, speed lathe, for centring and finishing, 3½-foot bed; 5, four wood-turning bench lathes, 5-foot bed; 6, machine planer, 3½-foot bed; 7, vertical drilling machine; 8, double emery-grinder; 9, grindstone; 10, scroll-saw; 11, small fret-saw; 12, circular saw, both rip and cross cutting; 13, Sturtevant blower; 16, shaft running between engine-house and shop; the pulleys, 14 and 15, distribute the power from this shaft to the line-shafts of the shops (not shown), by which all of the above machinery is driven; the shaft, 16, is coupled directly to the engine shaft; 17, nine wood-working benches; 18, vises to each bench; 19, two iron-working benches; 20, eight Parker vises for iron-work; 21, instructor's table; 22, table for student work; 23, closet for miscellaneous wood-working tools and supplies; 24, cabinet for chucks, drill-gear, etc., for the machines; 25, cabinet of closets for students' clothes; 26, closet for iron-work supplies, files, bolts, etc.; 27, sink provided with wash-basins; 28 and 29, cabinets for lathe-tools; 30, four wrought-iron forges; 34, four anvils; 35, four tool-racks; 36, portable forge; 37, case for forge-work; 38, bench; 39, vise; 40, racks for iron and steel; 41, closet for paints and oils;

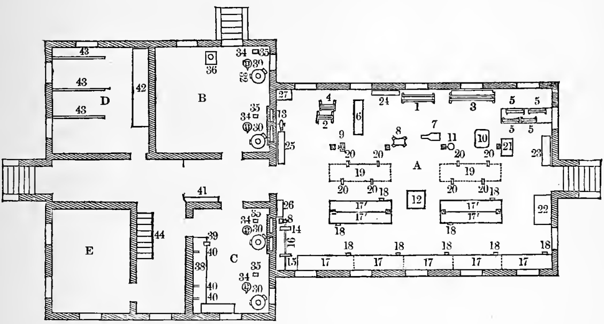
42, bench for storing small pieces of lumber; 43, rack for stock of lumber; 44, stairs to upper floor; 45, entrance steps.

The Shop Instruction is divided as follows: —

Bench-work in wood	12 weeks	(120 hours).
Wood-turning	4 weeks	(40 hours).
Pattern-making	12 weeks	(120 hours).
Vise-work in iron	10 weeks	(100 hours).
Forging in iron and steel	18 weeks	(180 hours).
Machine-tool work in iron	20 weeks	(200 hours).

The object of the shop instruction is, first, to prepare students for a course of mechanical engineering; and, second, as a preparation for some industrial pursuit.

Method of Instruction. — We have series of unchanging principles which must be taught practically through the use of corresponding sets of tools; and, while series of models are principally used, we vary these with each class in form and dimensions, always keeping in view the principles to be taught. Another feature is to make the models assume a form which may,



PLAN OF THE MECHANIC ARTS SHOPS, PURDUE UNIVERSITY.

if possible, afterwards be utilized. The principles involved will always be of *prime*, and the utilization of *secondary*, consideration.

Course in Carpentry and Joinery. — 1, Exercise in sawing and planing to dimensions; 2, application; a box nailed together; 3, mortise and tenon joints; a plain mortise and tenon; an open dovetailed mortise and tenon (dovetailed halving); a dovetailed keyed mortise and tenon; stock 2″ thick, worked to $1\frac{3}{4}$″; mortise pieces 10″ long, and tenon pieces 6″ in the clear; 4, splices; 5, common dovetail; 6, lap-dovetailing and rabbeting; 7, blind or secret dovetail; 8, mitre-box; 9, carpenter's trestle; 10, panel-door; 11. roof-truss; 12, section of king-post truss roof; 13, drawing models. Elements applied in simple forms in each case.

Wood-Turning. — 1, Elementary principles, 1st straight turning, 2d cutting in, 3d convex curves with the chisel, 4th compound curves formed with the gouge; 2, handles; 3, mallets; 4, picture-frames (chuck-work); 5, card-receiver (chuck-work); 6, match-safe (chuck-work); 7, ball. The articles

present good forms for learning the art, and each of the last three a new and difficult feature of chucking.

Pattern-Making. — The student is supposed now to have some skill in bench and lathe work, which will be increased; but the direct object is to teach what forms or patterns are in general necessary, and how they must be constructed in order to get a perfect mould from them. We have not thought it necessary that each student should do the same examples to accomplish this object. In this way the work has been much more varied: each student learns the particular features in the work done by his neighbor, and gets a much broader knowledge than could in the same time be acquired in any other way. Besides simple patterns easily drawn from the sand, such as glands, ball-cranks, etc., there followed a series of flanged pipe-joints for $2\frac{1}{2}''$ pipe, including the necessary core-boxes, in which all took part; then pulley patterns from $6''$ to $10''$ in diameter, built in segments for strength, and to prevent warping and shrinkage; lastly, a complete set of patterns for a three-horse-power horizontal steam-engine, all made from drawings of the finished piece.

Vise-Work in Iron. — 1. Given a block of cast iron $4''$ by $2''$ by $1\frac{1}{2}''$ in thickness, to reduce the thickness $\frac{1}{4}''$ first by chipping, and then finish with the file. 2. To file a round hole square. 3. To file a round hole into an elliptical one. 4. Given a $3''$ cube of wrought iron, to cut a spline $3''$ by $\frac{3}{8}''$ by $\frac{1}{4}''$, and, 2d, when the under side is a one-half round hollow. These two cuts involve the use of the cape-chisel, and the round-nose chisel, and are examples of very difficult chipping. 5. Round filing, or hand vise-work, with the same examples as are given in the cut illustrating the course at the Institute of Technology. 6. Scraping. 7. Some special examples of fitting.

Forging. — 1. Elementary processes, drawing, bending, upsetting. 2. A course in welding. 3. Miscellaneous forgings. 4. Steel-forging, including hardening and tempering.

Machine-Work. — In this course we have used no set models, the work varying more or less with each class. But the aim is to teach centring, plain and taper turning, taper fitting, screw cutting, to bring in all the adjuncts of the machines, and to give practice in their use. All students are not upon the same work at the same time; but each during his course has an opportunity of learning the use of all the tools and appliances. Nor is a given time allotted to each piece. The slow ones must work extra time to keep up, while those who are quick are given extra work. All students are required to devote all the time allotted to each shop course, and not allowed to pass from one to another in advance of the class, unless they are proficient and can enter a regular class in an advanced branch.

The shop instruction is supplemented by a course of lessons on the theory of the hand and machine tools; more or less use being made of Shelley's "Workshop Appliances," Rose's "Practical Machinist," and notes found in the first two volumes on "Building Construction" published by Rivingtons.

I regret that I cannot devote more space to Mr. Goss's interesting account of the good work he is doing at Purdue, which is heartily indorsed by President White.

THE MANUAL TRAINING SCHOOL

OF WASHINGTON UNIVERSITY, ST. LOUIS, ESTABLISHED JUNE 6, 1879.

Professor C. M. Woodward, the director of this school, has furnished me with the following details of cost, the cuts representing the building and floors, and the excellent statement hereto appended. Building cost twelve thousand dollars; tools and furniture, eleven thousand; land, six thousand: total, twenty-nine thousand dollars. About one-third of the one hundred and two pupils are on free scholarships held by the founders. Mr. Samuel Cupples pays two hundred and fifty dollars per month for five years (fifteen thousand in all) for current expenses. This with tuition-fees will about cover expenses for the five years from date of foundation.

General Statement.

Conditions of Admission. — Candidates for admission to the first-year class must be at least fourteen years of age, and each must present a certificate of good moral character signed by a former teacher.

They must also pass a good examination on the following subjects: —

1. Arithmetic; including the fundamental rules, common and decimal fractions, the tables of weights, measures, and their use. Candidates will be examined orally in mental arithmetic, including fractions and the multiplication-table up to twenty. 2. Common-school geography. 3. Spelling and penmanship. 4. The writing of good English.

Candidates for the second-year class must be fifteen years of age. All that is specified above will be required of them, and, in addition, the studies and shop-work of the first year.

Similar requirements apply to those desiring to enter the third-year class.

Course of Study. — The course of instruction covers three years, and the school-time of the pupils is about equally divided between mental and manual exercises. Neither intellectual nor physical labor is carried to the extent of weariness.

The change from recitation to the shop, and from shop to study and recitation, is agreeable and healthful, keeping both mind and body fresh and vigorous.

Mental Training. — In mathematics the course of instruction is thorough, but not extended. Arithmetic, algebra, geometry, and plane trigonometry are studied in succession. The application of these branches is made in book-keeping, mechanical drawing, physics, mechanics, and mensuration.

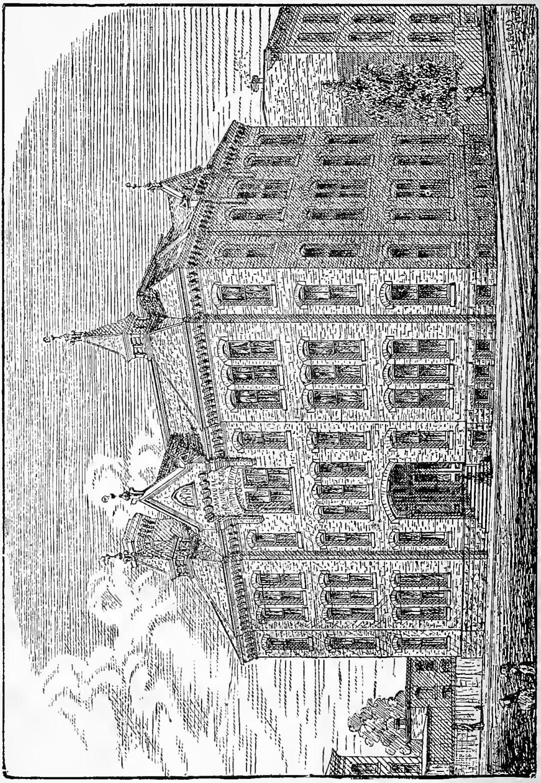
Careful attention is given to physical geography.

The English language and literature is carefully studied throughout the

course. Every graduate of the school will have fair command of the English language, whether in writing or speaking.

History, practical ethics, and political economy each finds a place on the programme, the treatment of each subject being adapted to the capacity of the class.

Manual Training. — Special attention is paid to drawing during the



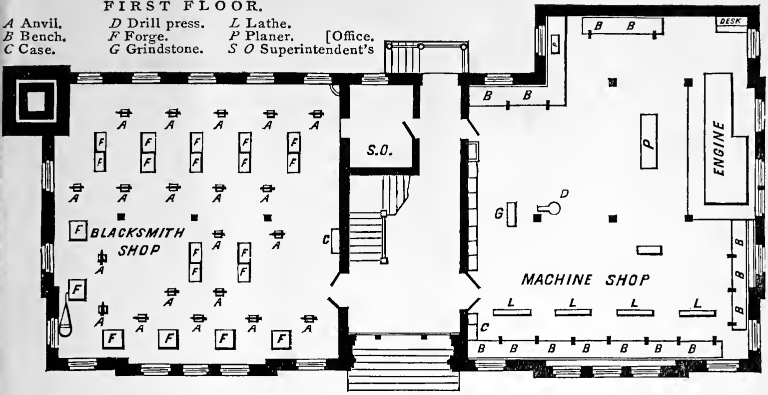
MANUAL TRAINING SCHOOL, WASHINGTON UNIVERSITY, ST. LOUIS.
(*Floor Plans on opposite page.*)

whole course. Drawing is the shorthand language of modern science. Careful drawings are to technically educated people what pictures are to children. They show at a glance what it is not in the power of words to express. It is a universal language, and should be read and understood by all.

The course in drawing embraces three general divisions: —

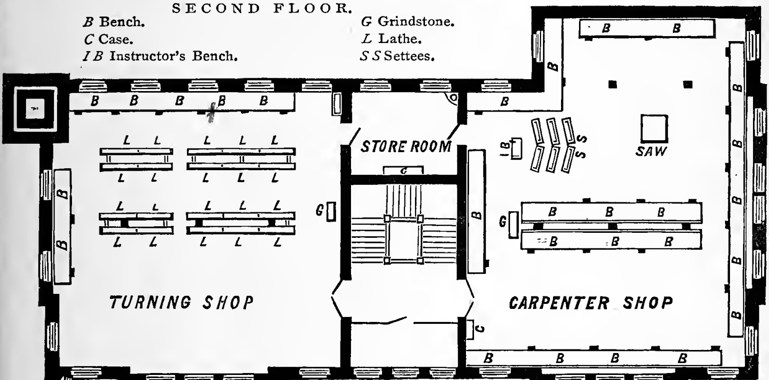
FIRST FLOOR.

A Anvil. *D* Drill press. *L* Lathe.
B Bench. *F* Forge. *P* Planer.
C Case. *G* Grindstone. *S O* Superintendent's [Office.



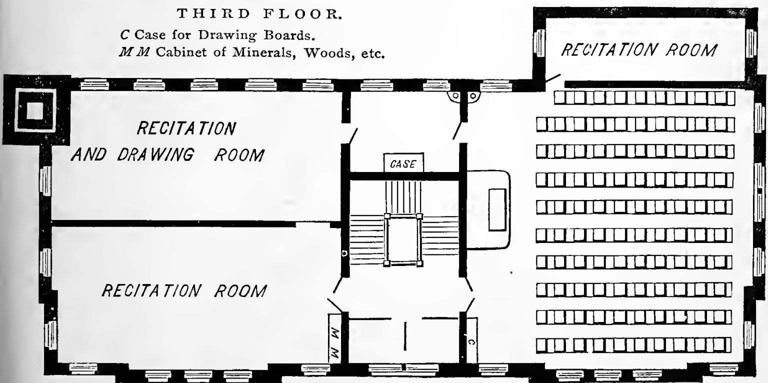
SECOND FLOOR.

B Bench. *G* Grindstone.
C Case. *L* Lathe.
I B Instructor's Bench. *S S* Settees.



THIRD FLOOR.

C Case for Drawing Boards.
M M Cabinet of Minerals, Woods, etc.



1. *Freehand Drawing*, designed to educate the sense of form and proportion, to teach the eye to observe accurately, and to train the hand to rapidly delineate the forms either of existing objects or of ideals in the mind.

2. *Mechanical Drawing*, — including the use of instruments; geometric constructions ; the arrangement of projections, elevations, planes, and sections ; also the various methods of producing shades and shadows with pen or brush.

3. *Technical Drawing or Draughting*, — illustrating conventional colors and signs; systems of architectural or shop drawings; and at the same time familiarizing the pupil with the proportions and details of various classes of machines and structures.

Workshop Instruction. — In connection with drawing comes instruction in the nature, theory, and use of tools.

But which are the tools whose use is to be taught? Before answering this question, it is to be observed that the apparently great variety in tools and mechanical processes arises from different combinations of very simple elements. The number of hand-tools is small: one can easily count them on his fingers. They are the *axe*, the *saw*, the *plane*, the *hammer*, the *square*, the *chisel*, and the *file*. The study of a tool involves an examination of its form and the theory of its action, as well as its actual use at the bench or forge. After the hand-tools, pupils should become familiar with the typical machine-tools which are chiefly employed in mechanical pursuits.

A knowledge of materials and processes is as important as an acquaintance with tools. The characteristic properties of different kinds of wood; the difference between cast and wrought iron; the properties of steel, brass, and other materials, — these are learned only by actual contact and personal investigation.

Then the student should understand the relation between different kinds of work, their sequence and mutual dependence.

Thus the making of patterns precedes the use of castings. The castings themselves are planed, bored, drilled, and turned, by the use of special machine-tools. Wrought iron and steel are worked at the forge previously to being used in the machine-shop.

Study and Management of Steam. — The steam-generating apparatus of the university consists of a battery of three large steel boilers set and furnished in the most approved manner. These boilers furnish heat for the entire group of university buildings, as well as steam for the engine in the shop. The engine is of the best pattern and superior workmanship, and is capable of about sixty horse-power. During their second and third years the pupils make a careful study of the engine and furnaces, and are practised in the management and care of them both.

Project for Graduation. — Before receiving a diploma of the school, each student must execute a project satisfactory to the faculty of the school. The project consists of the actual construction of a machine. The finished machine must be accompanied by a full set of the working-drawings according to which the machine is made. If it is not feasible to construct the patterns for castings of such machine, proper directions for their construction must accompany the drawings.

Students have no option or election as to particular studies; each must conform to the course as laid down, and take every branch in its order.

The arrangement of studies and shop-work by years is substantially as follows : —

First Year. — Arithmetic, completed; algebra, to equations; English language, its structure and use; history of the United States; physical geography; drawing, mechanical and freehand; penmanship; carpentry and joinery; wood-carving; wood-turning; pattern-making.

Second Year. — Algebra, through quadratics; geometry, plane; natural philosophy; English history; English composition and literature; principles of mechanics; penmanship; drawing, line-shading and tinting machines, freehand detail drawing; blacksmithing, drawing, upsetting, bending, punching, welding, tempering; use of machine-tools.

Third Year. — Geometry, solid; plane trigonometry and mensuration; English composition and literature; history; ethics and political economy; book-keeping; drawing, machine and architectural; study of the steam-engine; bench-work and fitting; work in the machine-shop, turning, drilling, planing, screw-cutting, etc.; execution of project.

DAILY PROGRAMME. FIRST TERM — 1881-82.

Classes.	Divisions.	9 — 11 A.M.	11 A.M. — 1 P.M.	1 — 3 P.M.
Second Year.	A.	Shop-work.	40 min. Algebra 40 min. English History 20 min. Study. 20 min. Recess.	40 min. Physics 20 min. Study. 60 min. Draw'g.
	B.	60 min. Draw'g. 20 min. Study. 40 min. Algebra	Shop-work.	20 min. Recess. 20 min. Study. 40 min. Physics 40 min. English History
First Year.	A.	Shop-work.	60 min. Draw'g. 20 min. Recess. 40 min. Gram'r.	40 min. Arith. 40 min. Study. 40 min. Physic'l Geog.
	B.	40 min. Gram'r. 20 min. Study. 60 min. Draw'g.	Shop-work.	20 min. Recess. 20 min. Study. 40 min. Arith. 40 min. Physic'l Geog.
	C.	40 min. Arith. 40 min. Study. 40 min. Physic'l Geog.	40 min. Gram'r. 20 min. Recess. 60 min. Draw'g.	Shop-work.

NOTES : 1. — Penmanship takes the place of Physical Geography and Physics once a week.
2. — Each class has Music Lesson once a week, extending the daily session half an hour.
3. — Composition takes the place of Grammar and History once a week.
4. — Spelling occupies half the study time three times a week.

Description of the Shops and Tools. — The second floor of the building is devoted to woodwork, and comprises a carpenter-shop, store-room, and turning-shop. Each shop has uniform accommodations for classes of twenty pupils. Four such classes or divisions can be taught daily in each. Each pupil has one of the uniform sets of edge-tools for his exclusive use, kept in a locked drawer. For the care and safety of these tools he is held responsible. Other tools, such as squares, hammers, wrenches, etc., are provided for the use of each class in succession.

The Carpenter-Shop. — This contains twenty benches, vises, and sets of tools for use in common, a power grindstone, the instructor's desk and bench, settees for the class, and the requisite quota of clamps, glue-pots, etc. A double circular-saw machine is provided for getting out stock ("blanks" for a class) and jobbing.

The Turning Shop contains twenty speed lathes, twelve-inch swing and five-foot bed, with complete equipment of face-plates, chucks, etc., for eighty pupils. The shop contains several eight-foot benches for pattern-work, a power grindstone, and a moulder's bench, and tools for illustrating practically the use and handling of patterns for foundery-work.

The Machine-Shop. — The first floor of the building is devoted to metal-work, and comprises the machine and blacksmith shops. At present (December, 1881) the machine-shop is not in use by the pupils of the Manual Training School. [The school has not been in operation quite a year and a half, and hence the students have not yet reached this shop in their course.] It possesses but a partial equipment, consisting of four engine-lathes of fourteen-inch swing and five-foot bed; a speed lathe; a planer, twenty-one-inch by twenty-one-inch by five feet; a twenty-five-inch drill, and a large power grindstone. Ten vises and benches, with forty drawers, afford opportunity for bench-work. By September, 1882, it is expected that this shop will be furnished for a class of twenty students at once. The engine occupies a part of this shop.

The Blacksmith-Shop has its complete equipment of twenty forges, anvils, tubs, and sets of ordinary hand-tools. Ten sets of heavy tools suffice for twenty pupils, as they may work in pairs as "smith and helper." The blast is supplied by a fan blower, and a powerful exhaust fan keeps the shop completely free from smoke and gas. In connection with one of the larger forges is a hand-bellows, which can be used when the engine is not running. Every shop exercise lasts two hours: consequently the shop readily accommodates eighty pupils per day.

All the machinery of the shops is driven by a fine Corliss engine, fourteen-inch cylinder and forty-two-inch stroke, running at sixty-five revolutions per minute. The engine was built specially for the school by Messrs. Smith, Beggs, & Rankin, of St. Louis. Steam is furnished from the university boilers. The building is heated by the exhaust steam from the engine. This equipment of steam-power will furnish to pupils of the third-year class the means of becoming familiar with such machinery on a scale unsurpassed.

The shops throughout contain ample conveniences for the shop-clothing of the pupils, and the basement contains facilities for washing with hot and cold water.

The drawing-room and the two recitation-rooms are on the third floor.

All the shops and other rooms are spacious, and amply lighted, well warmed and ventilated. The location of the building, on the south-west corner of Eighteenth Street and Washington Avenue, is one of the best in the city, being high and healthful.

The Theory of Shop-Work. — The application of the educational idea to mechanic arts is strictly analogous to its application to chemistry and physics. In each, the use of apparatus and the treatment of material is taught by systematic experiments in suitable laboratories. In each, every thing is arranged for the purpose of giving instruction in the principles involved, and for acquiring skill in manipulation, and not for the sake of the production of salable compounds of either drugs or apparatus.

Chemical laboratories might be manufactories, and mixtures might be

made for sale, but the efficiency of such a laboratory for the purpose of education would be very small. So a manufacturing establishment can be made a place for instruction in the use of tools, but its cost would be great in proportion to its capacity, and the variety of work would be limited by its business.

Special Trades are not taught. — The scope of a single trade is too narrow for educational purposes. Manual education should be as broad and liberal as intellectual. A shop which manufactures for the market, and expects a revenue from the sale of its products, is necessarily confined to salable work; and a systematic and progressive series of lessons is impossible, except at great cost. If the object of the shop is education, a student should be allowed to discontinue any task or process the moment he has learned to do it well. If the shop were intended to make money, the students would be kept at work on what they could do best, at the expense of breadth and versatility.

It is claimed that students take more interest in working upon something which, when finished, has intrinsic value, than they do in abstract exercises. This is quite possible, and proper use should be made of this fact; but, if all education were limited to such practical examples, our schools would be useless. The idea of a school is that pupils are to be graded and taught in classes; the result aimed at being not at all the objective product or finished work, but the intellectual and physical growth which comes from the exercise. Of what use is the elaborate solution in algebra, the minute drawing, or the faithful translation, after it is well done? Do we not erase the one, and burn the other, with the clear conviction that the only thing of value was the discipline, and that that is indestructible?

So in manual education, the desired end is the acquirement of skill in the use of tools and materials, and not the production of specific articles: thence we abstract all the mechanical processes and manual arts and typical tools of the trades and occupations of men, arrange a systematic course of instruction in the same, and then incorporate it into our system of education. Thus, without teaching any one trade, we teach the essential mechanical principles of all.

In accordance with the foregoing principles, the shop training is gained by regular and carefully graded lessons designed to cover as much ground as possible, and to teach thoroughly the uses of ordinary tools. This does not imply the attainment of sufficient skill to produce either the fine work or the rapidity of a skilled mechanic; this is left to after-years. But a knowledge of how a tool or machine should be used is easily and thoroughly taught. The mechanical products or results of such lessons have little or no value when completed, and hence the shops do not attempt to manufacture for the market.

As has been said, work of immediate utility is of greater interest to students than abstract lessons. Such work has an undoubted value, and is in many ways desirable, provided it does not hinder or interfere with regular instruction. Opportunities for such constructive work are constantly occurring. The wants of a large institution are many, and when they can be supplied by student skill it is a benefit to all concerned. In this way, outside the stated hours, pupils have the means of applying their knowledge and of

gaining additional practice. The yearly aggregate of such productions is quite large, and it affords undeniable evidence of the efficiency of systematic instruction.

Details of Shop Instruction. — The shop instruction is given similarly to laboratory lectures. The instructor at the bench, machine, forge, or anvil, executes in the presence of the whole class the day's lesson, giving all needed instructions, and at times using the blackboard. When necessary, the pupils make notes and sketches, and questions are asked and answered, that all obscurities may be removed. The class then proceeds to the execution of the task, leaving the instructor to give additional help to such as need it. At a specified time that lesson ceases, the work is brought in, commented on, and marked. It is not necessary that all the work assigned should be finished: the essential thing is, that it should be well begun and carried on with reasonable speed and accuracy.

It is almost useless to say that the personal characteristics of pupils are even more marked in this work than in any ordinary recitation, from the fact that no text-books are used, nor is there previous study. The length of time required by different pupils in a large class for the doing of a specified piece of work varies considerably, Hence additional lessons or constructive work are arranged for the brighter and quicker members.

Work in the blacksmith-shop is in one essential feature different from any other kind. Wood or cold iron will wait any desired length of time while the pupil considers how he shall work, but here comes in temperature subject to continual change. The injunction is imperative to "strike while the iron is hot," and hence quick work is demanded, — a hard thing for new hands. To obviate this difficulty, bars of lead are used, with which the lesson is first executed, while all the particulars of holding and striking are studied. The lead acts under the hammer very nearly like hot iron, and will permit of every operation of the blacksmith's shop except welding. Much is anticipated from its use as a preparation for the working of iron, as each lesson is first executed in lead.

One of the most difficult lessons in the art of the smith is that of managing the fire. The various kinds of heat are explained and illustrated, and habits of economy of both iron and fuel are inculcated.

How the Use of Tools is taught. — Frequent requests have been made for detailed descriptions or drawings of the models actually used in the several shops. Such requests have generally been refused, for several good reasons. In the first place, the main object of one or more lessons is to gain control and mastery of the tool in hand, and not the production of a particular model. The use of the tool may be well taught by a large variety of exercises, just as a knowledge of bank discount may be gained from the use of several different examples. No special merit can be claimed for a particular example; neither can a particular model, or series of models, have any great value. No good teacher is likely to use precisely the same set twice.

Again, the *method* of doing a piece of work, and not the finished piece, may be the object of a lesson. To illustrate: Directions are given to a class in carpentry to saw a piece of wood, holding it upon the bench-dog. A pupil is found attempting to do the work, holding it on a trestle. On being corrected, he insists that he can't do it so well in that way. The teacher

replies, or should reply, "Then that is the way you should do it, until you can do it well." Now, the exercises by which certain methods of using tools are to be taught often depend upon varying circumstances, such as the quality of the material, the age of pupils, and the pupils' knowledge of working-drawings. Instead of giving particular descriptions of exercises, we prefer to state the general methods by which the use of the various tools is taught.

The tools are not given out all at once: they are issued as they are needed, and to all the members of the class alike.

In carpenter-work the tools used are, the crosscut, tenon, and rip saws; steel square, try-square, bevel and gauge, hammer, mallet, knife, rule and dividers, oil-stones and slips; and, of edge-tools, the jack and smoothing planes, the chisel, and gouges. Braces and bits, jointer planes, compass saws, hatchets, and other tools are kept in the shop tool-closet, to be used as needed.

The saw and the plane, with the square and gauge, are the foundation tools; and to drill the pupils in their use numerous lessons are given, varied only enough to avoid monotony. The pupil being able to plane a piece fairly well, and to keep to the line in sawing, the next step is to teach him to add the use of the chisel in producing simple joints of various kinds. The particular shapes are given with the intent to familiarize the pupil with the customary styles and methods of construction.

The different sizes of the same tool (chisels, for instance) require different care, and methods of handling; and the means of overcoming irregularities and defects in material form another chapter in the instruction to be given.

With the introduction of each tool, the pupils are taught how to keep the same in order. They are taught that sharp tools are absolutely necessary to good work: to make them realize this, is a most difficult task.

Turning. — In a general way much that has already been stated applies to wood-turning. Five or six tools only are used, and from previous experience the pupils know how to keep them in order. At first a large gouge only is issued, and the pupils are taught and drilled in its use in roughing out and producing right-line figures; then convex and concave surfaces; then in work comprising all these, — all in wood-turning with the grain. A wide chisel follows, and its use in conjunction with the gouge is taught. After this, a smaller gouge, chisel, and parting-tool, and a round-point are given, and a variety of shapes are executed. Next comes turning across the grain; then bored and hollow work. Next, chucking, and the various ways of manipulating wood on face-plates, chucks, mandrels, etc. Finally, turning of fancy woods, polishing, jointing, and pattern work.

Of the course in iron-work nothing must as yet be said, for the reason that we desire to speak only of work gone over, and that department is not yet fully developed.

The Origin and Purpose of the School. — The Manual Training School owes its existence to the conviction on the part of its founders that the interests of St. Louis demand for young men a system of education which shall fit them for the actual duties of life in a more direct and positive manner than is done in the ordinary American school.

We see in the future an increasing demand for thoroughly trained men to take positions in manufacturing establishments as superintendents, as

foremen, and as skilled workmen. The youth of to-day are to be the men of the next generation. It is important that we keep their probable life-work in view in providing for their education. Excellent as are our established schools, both public and private, it must be admitted that they still leave something to be desired; they do not, and probably they cannot, cover the whole ground.

It is believed that to all students, without regard to plans for the future, the value of the training which can be got in shop-work, spending only from four to twelve hours per week, is abundantly sufficient to justify the expense of materials, tools, and expert teachers.

It is very well understood that many students cannot wisely undertake the full course of intellectual study now laid down for the regular classes of a college or polytechnic school. It occasionally happens that students, who have special aptitudes in certain directions, find great difficulty in mastering subjects in other directions. In such cases it is often the best course to yield to natural tastes, and to assist the student in finding his proper sphere of work and study. A decided aptitude for handicraft is not unfrequently coupled with a strong aversion to and unfitness for abstract and theoretical investigations. There can be no doubt, that, in such cases, more time should be spent in the shop, and less in the lecture and recitation room.

One great object of the school is to foster a higher appreciation of the value and dignity of intelligent labor, and the worth and respectability of laboring men. A boy who sees nothing in manual labor but mere brute force despises both the labor and laborer. With the acquisition of skill in himself, comes the ability and willingness to recognize skill in his fellows. When once he appreciates skill in handicraft, he regards the workman with sympathy and respect.

In a manual training school, tool-work never descends into drudgery. The tasks are not long, nor are they unnecessarily repeated. In this school, whatever may be the social standing or importance of the fathers, the sons go together to the same work, and are tested physically as well as intellectually by the same standards. The result in the past has been, and in the future it will continue to be, a truer estimate of laboring and manufacturing people, and a sounder judgment on all social problems.

The Results of Experience.

The managers of the school are abundantly confirmed in their views, as set forth in the prospectus two years ago, by the experience of the school during its first year and a half.

From the first the school has been well patronized, and vacant seats have been few. At times every seat has been filled. The school was opened with sixty seats, all for a single class.

The entire number of students enrolled during the first year was sixty-four. The number of seats was increased to one hundred during the last summer. The number of students enrolled thus far this year is one hundred and two, of whom forty-two were members of the school last year.

The zeal and enthusiasm of the students has been developed to a most gratifying extent, extending into all the departments of work. The variety afforded by the daily programme has had the moral and intellectual effect

expected, and an unusual degree of sober earnestness has been shown. Success in drawing or shop-work has often had the effect of arousing the ambition in mathematics and history, and *vice versa.*

Progress in the two subjects, drawing and shop-work (and we had little previous knowledge of what could be done with boys as young as those of the first-year class), has been quite remarkable. To be sure, there was no doubt of the final result; but the progress has been more rapid than it seemed reasonable to expect. The second-year class contains already several excellent draughtsmen, and not a few pattern-makers of accuracy and skill. The habit of working from drawings and to nice measurements has given the students a confidence in themselves altogether new. This is shown in the readiness with which they undertake the execution of small commissions in behalf of the school, or for the students of other departments. In fact, the increased usefulness of our students is making itself felt at home, and in several instances the result has been the offer of business positions too tempting to be rejected. This drawback, if it can be called one, the school must always suffer. The better educated and trained our students become, the stronger will be the temptations offered to them outside, and the more difficult it will be for us to hold them through the course. Parents and guardians should avoid the bad policy of injuring the prospects of a promising son or ward, by grasping a small present pecuniary advantage, at the cost of far greater rewards in the future.

Success of the Russian Plan. — In another important respect our expectations have been more than realized; namely, in our ability to introduce class methods in giving instruction in the theory and use of tools. All divisions in the shops have thus far been limited to twenty pupils; and, as a rule, all members of a division have just the same work.

The exercises have been two hours long, though often the students have asked for longer work. It is but due to the pupils of the school to say that they have uniformly seconded all efforts looking towards good order and good manners. No little surprise has been expressed by visitors, at seeing how quietly and independently twenty boys can work for a couple of hours in the same room. Though all classes handle keen-edged tools, no serious accident has happened, and very rarely have small injuries been received.

There are three schools in France which I had the pleasure of visiting in 1878, which will prove instructive. — First,

THE ÉCOLE COMMUNALE,

RUE TOURNEFORT, PARIS.

This is an elementary school containing between two and three hundred pupils ranging in age from eight or nine to fourteen or fifteen years of age. The prescribed course is three years; and, besides the studies suitable to the age of such

pupils, three points will attract our attention: first, the free-hand drawing, which is excellent, showing the best of teaching; second, modelling in clay, and duplicating the best specimens in plaster; and, third, shop-work in wood and the metals, taken by about fifty of the older pupils. The modelling would have been considered remarkable, for a much older class of pupils; and I saw nothing to compare with it, either in design or execution, outside of the special art schools. The facilities for shop instruction in the working of wood and metals were less complete, the shops being fitted to teach but few at a time. The mechanic art method is strictly followed, the samples used being those presumably best adapted to teach principles and processes, and having no marketable value, on the ground that articles made for sale cannot be so well adapted for systematic and progressive instruction. All commercial considerations are, on principle, scrupulously avoided. For two years the pupil has practice in the different shops; but in the third his shop instruction is confined to some specialty. I was both delighted and instructed by my visit; and left recognizing in M. Laubier, the genial head of the school, a man whose ample knowledge was quickened by a genuine enthusiasm and love of his work.

THE ÉCOLE MUNICIPALE D'APPRENTIS,

BOULEVARD DE LA VILLETTE, PARIS.

This is one of the best examples of a trade-school modified by the mechanic art idea. The course of instruction is three years. In January, 1873, it had seventeen pupils, and now numbers over two hundred. The principal feature of the school is its large and well-appointed machine-shops, arranged for manufacturing purposes. The aim of the school is to turn out good workmen. During the first year the student works, two weeks at a time, in the various shops, after which he devotes himself to a particular specialty; that is, he learns the trade of a machinist, a carpenter, a joiner, a pattern-maker, a founder, or a blacksmith, in much the same way that an apprentice in any well-appointed establishment would learn the same specialty. As there are only three foremen, it is obvious that the amount of instruction given to each student must be very small.

The time, from seven A.M. to half-past two P.M., is divided as follows: from seven to eight, study; from eight to eleven, shop-work; from eleven to twelve, breakfast, recreation, and gymnastics; from twelve to half-past twelve, shop-work; from half-past two to three, recess and lunch.

Scheme of Study and Work from 3 to 7 P.M.

Day.	Year.	3 to 4.	4 to 5.	5 to 6.	6 to 7.
MONDAY.	1st.	Study.	Geometry.	French.	Geometry.
	2d.	Geometry.	Study.	Geometry.	English.
	3d.	Workshop.	Workshop.	Drawing.	Law.
TUESDAY.	1st.	Drawing.	Drawing.	Study.	English.
	2d.	Study of Tools.	Study.	Algebra.	Hist. and Geog.
	3d.	Workshop.	Workshop.	Mechanics.	Descriptive Geometry.
WEDNESDAY	1st.	History.	Chemistry.	French.	Geometry.
	2d.	Drawing.	Drawing.	Geometry.	Physics.
	3d.	Workshop.	Workshop.	Drawing.	Sketching.
THURSDAY.	1st.	Reading.	Geography.	Arithmetic.	English.
	2d.	French.	Chemistry.	English.	Arithmetic.
	3d.	Workshop.	Workshop.	Physics and Chemistry.	Technology.
FRIDAY.	1st.	Drawing.	Drawing.	French.	Geometry.
	2d.	Mechanics.	Book-keeping.	Geometry.	Study.
	3d.	Workshop.	Workshop.	Mechanics.	Sketching.
SATURDAY.	1st.	Study of Tools.	Arithmetic.	Physics.	Study.
	2d.	Drawing.	Drawing.	French.	Study.
	3d.	Workshop.	Workshop.	Drawing.	Sketching and Drawing.

It will be seen from the above that for the first two years the mornings are devoted to shop-work, and the afternoons to other studies; that for the third year the shop-work continues till five P.M., and the time from five to seven is devoted to other subjects. The amount of shop-work accords with the aim of the school to make good workmen.

THE ÉCOLE D'APPRENTIS

AT CHALONS-SUR-MARNE, FRANCE.

This old and famous school well deserves its high reputation, as one of the best appointed and thorough trade-schools in

Europe. It is literally a school in a large manufacturing establishment, where manual skill and technical knowledge of some special trade is the main object, but supplemented by drawing and such other studies as a skilled mechanic needs. Its aim is to make foremen, constructors, and directors of works, rather than engineers or ordinary workmen. The apprentice-school on Boulevard de la Villette, Paris, is an almost exact model of that at Chalons, but not of so high a grade. The Chalons scheme of studies and shop-work is so similar, that a more detailed statement is unnecessary. Its students are older; the shops have a larger number of foremen to direct the work of the students, and a more complete equipment. In its shop instruction it has in later years conformed more nearly to mechanic art methods, particularly in the earlier part of the course.

THE ROYAL AGRICULTURAL AND FORESTRY ACADEMY

AT HOHENHEIM, WÜRTTEMBERG, GERMANY.

Hohenheim was once a ducal summer palace. It is two hours by post from Stuttgart, about thirteen hundred feet above the sea, and nearly five hundred feet above the valley of Stuttgart. The old palace, with its turrets and pinnacles, its courts and quadrangles, and its once white walls, now gray and hoary with age, all in strong contrast with the emerald green of early spring which surrounded it at the time of my visit, made a picture not soon to fade from the memory. The little hamlet of Hohenheim contained, in 1875, including students, about three hundred inhabitants and thirty families. The palace contains a hundred and twenty rooms for students, besides ample space for all the purposes of the school.

The general studies include the elementary mathematics, with trigonometry and descriptive geometry, physics and chemistry, and the natural sciences which apply in farming, fruit and forest culture, and the raising and training domestic animals. The practical studies include the history and literature of farming, farm productions in general, with special practical instruction relating to the culture of hops, grapes, fruits, and vegetables, the breeding, rearing, diseases, and uses of domestic animals, the production of wool and silk, and bee-culture, farm

management, with practice in the drawing of plans and specifications for such management, and farm book-keeping: farming technology taught through practice. There is a corresponding practical course for forestry. The farm contains 971$\frac{3}{8}$ German acres, or about 780 of ours, devoted as follows: arable land, about 613 acres; meadows, 161; hop-garden, 4; practice-field, 28; farm-practice station with practice-fields, 6; practice-garden for forestry, 1; rented pieces of ground, 14; exercise-field, 2; fruit-tree culture-ground, 17; vegetable garden, 6; botanic garden, 15; mulberry plantation, $\frac{3}{8}$; vineyard, $\frac{3}{8}$; constant pasture, 22; roads, fish-pond, and commons, 51; wild forest-tree plantation, 13; yards and building-space, 17; and cemetery, $\frac{1}{8}$ of an acre. There are, besides, about fifty-five hundred acres of hunting-forest in Hohenheim, in charge of the professor of forestry, which are available to the students of this department. The collections include models of farm machines and tools, mostly natural size, forest productions and forest technology, the cabinets of mineralogy, botany, zoölogy, and physics, the veterinary arts and horse-shoeing, wools, soils, and composts; the library of ten thousand volumes; the workshops for brandy distillation, for beer brewing, for beet-sugar manufacture, with conveniences for the preparation of starch, mustard, and vinegar. There is also a station for testing seeds, a meteorological station, and a silk-reeling station. There is also a manufactory of farm machinery and tools, employing from thirty to thirty-six men, two or three of whom devote themselves to making models.

This is a strictly special and practical professional school, and all the theoretical and applied instruction is so given as to educate the student toward and for his profession, and not away from it. While educating the student to a love of nature may not be one of the special aims of the school, it is difficult to conceive that a young man can spend two or three of his most susceptible years in such charming relations to nature, and not become her admirer and devoted servant for life. But the love of nature is strong in the German character; and many more young Germans than Americans, under the same circumstances, would voluntarily choose a profession the practice of which would be a constant source of gratification and pleasure.

There is also in Hohenheim, under the direction and supervision of the Bureau of Agriculture, a

Farm School,

the aim of which is to fit young men, especially peasants, by means of suitable practical teaching and practice in the fields connected with the school, to cultivate in a superior manner their own ground, as well as to train good land-tenants and overseers. The head master or principal of the school, besides the general direction, must give the theoretical instruction, except the doctoring of animals. He must be able to give instruction in the simplest operations of land-measuring. In field-work the pupils are in charge of an inspector or field-master, who carefully instructs them in the current farm-work of the season. The master having charge of all the farm tools and implements teaches the pupils how to use the horses and cattle devoted to farm-work, with their feeding and care. Forgetfulness, want of care, or cruel treatment of the animals must be brought to the attention of the board of directors. The school is fitted for twenty-five pupils, the course of instruction being three years. In the summer a few special pupils are admitted, who wish to practise some special branch. These must pay three florins per month for board and instruction. The regular students pay for board and instruction by their labor. They must furnish their own clothing, and pay for washing.

Conditions of Admission. — Pupils enter the school in October. Each applicant must be over seventeen years of age, and must bring a certificate from parent or guardian, or his baptismal certificate, and agree to remain three years and do the required work. He must be perfectly well and strong, so as to bear the fatigue of the necessary work, be able to read, write, and cipher, and must possess some knowledge of the use of agricultural tools.

The Instruction. — The head master gives four lessons per week, except during some periods of pressing work. Besides, in winter and on rainy days after supper, pupils must work out examples, or occupy themselves with other profitable study. But the work is so arranged that the course of in-door instruction can be completed in the three years. The hours of work, including instruction and the time devoted to the care of the working cattle, are ten hours per day in spring, summer, and autumn, and seven to eight hours per day in winter. In the summer, during harvest time, if work is pressing, one to two

hours per day are added. Besides board and tuition, the school furnishes the pupil with a warm room, which he uses as a dining and study room, a bedroom, and a sick-room when ill, and also the ordinary drink, light, books, bed, sheets, towels, etc. For poor pupils the Bureau of Agriculture also provides clothing out of a small fund for this purpose.

The studies are divided into six sections, one for each half-year of the course. In this way pupils may enter at the beginning of any section, and complete the course in the following three years.

Principal Studies. — 1. Climate, with geography; soils, with references to origin, to chemistry, and physics; manuring. 2. General plant-cultivation, with references to botany; working the soil, and the use of the implements; seeds and their care; the harvest; elementary principles in succession of crops. 3. Special cultivation of plants; meadows; fruit-trees; grapes; the products of ploughed land in particular. 4. General breeding of animals, with reference to zoölogy, and the required food; special, — cattle, horses, swine, bees. 5. Breeding of sheep; the farming profession; the improvement of the products from whey, flax, wine, and fruit manufactures. 6. Upon the fitting up and carrying on small farms, and better methods of cultivation; computations relating to income and expenses; farm buildings and land management.

Auxiliary Studies. — 1. German language (only in the winter half-year); (*a*) for the first class, exercises in easy subjects, as receipts, keeping of accounts, bills of lading, bills of exchange, etc.; (*b*) for the second class, keeping of accounts, contracts, etc.; (*c*) for the third class, compositions on agricultural subjects, oral statements, etc. 2. Arithmetic: (*a*) for the first class (both summer and winter half-year), the four rules in whole numbers and fractions; decimals; proportion; square root; mental exercises; (*b*) for the second class, profit and loss, interest, cube root, etc.; (*c*) for the third class, reduction, arithmetical progression. 3. Geometry: (*a*) first class, explanation of the elements, lines, angles, plane figures, circles, the three dimensions of objects, drawing, in summer, land-measuring; (*b*) for the second class (winter half-year), the more difficult propositions, surface computation, machine-drawing, in summer leveling and land-measuring; (*c*) for the third class (in winter half), computation of cubic contents, plan-drawing; in summer, prac-

tice in measuring solids and surfaces, freehand drawing. The instruction in animal doctoring is given in the three winter half-years, and divided as follows: 1. Internal and external diseases, with particular reference to the epidemic diseases, and means of prevention. 2. Medicines, simple operations, as bleeding, etc. 3. Exterior diseases, shoeing, principal wants, etc.

The lectures upon general physics are also divided in the winter half-years into the three following parts: 1. Simple rules of mechanics; 2. Heat, light, and explanations of the relating phenomena; 3. Electricity, with corresponding explanations.

Practical Studies.

I. *Field-Work.* — (*a*) Double teams. Pupils of the first and second years are taught to work with oxen, and the second and third year with horses. Pupils in their last half-year have charge of certain portions of the work. Common ploughing, harrowing, rolling, etc., are practised to such an extent during the three years, that the pupil can answer any demands made upon him. Practice in the use of the cultivator, drill-machine, and other implements not given in the first year, is had in the second and third, under the special instruction of the farm overseer. (*b*) Hand-work, manuring. This occupies the pupils when not busy with the teams, and includes loading and spreading it, especially upon the potato-fields. (*bb*) The sowing of gypsum by pupils of the first year; (*cc*) the sowing of different seeds, special study of the soil in connection therewith, in the second year. In the third year the pupils do the sowing themselves. (*dd*) Harvesting (reaping, mowing, binding, etc.) is done by the students and such day-laborers as are needed. (*ee*) The second and third year pupils are taught the rotting of flax and hemp.

II. *Work on Meadow-Land.* — (*a*) laying out of ditches; (*b*) irrigation; (*c*) work on drainage, the laying out of sewers and drains; (*d*) facing the water-banks; (*e*) work at hay and harvesting. In all this work the pupils take part, those of the third year usually acting as overseers.

III. *Fruit-Tree Culture* is taught by lectures and inspection, but the work is done by the pupils of the gardening and pomological school.

IV. *Work in the Hop-Garden* is done by the pupils of the first and second year, mainly under the direction of those of the third.

V. *Barn-Work.* — The threshing and cleaning of the various grains is done by the pupils when there is no other work on hand.

VI. *Working the Soil in Orchards* is given to the pupils in turn. The third-year pupils have practice in measuring and boxing fruits.

VII. *Work with Cattle.* — (*a*) Feeding oxen in summer, in winter; (*b*) milking cows; (*c*) care and rearing of calves; (*d*) care of fattening cattle. The pupils of the first and second year do the work *a b c* in turn. The weighing of fattened cattle is done by the older students.

(*e*) The opportunity is given the pupils to become acquainted with the care of bees.

VIII. *Manufacture of Agricultural Tools.* — Pupils who are qualified, and desire it, can spend some time in winter in the manufactory in Hohenheim.

IX. *Various Work.* — In general, the work of greasing the wagons, and making small repairs, is done by the upper servants; but the pupils must also learn from time to time how to do this work. The third-year pupils have charge of the harness-room, under the general oversight of the overseer. Pupils are also taught how to make straw-rope.

I have given full details in regard to this school, because I think that there are classes in our own country to be educated, to which such a school is particularly adapted. If I do not mistake, those interested in the Indian problem will find this example of especial value.

With one more example which interested me very much, and which may some time find an application in our own country, I close the list.

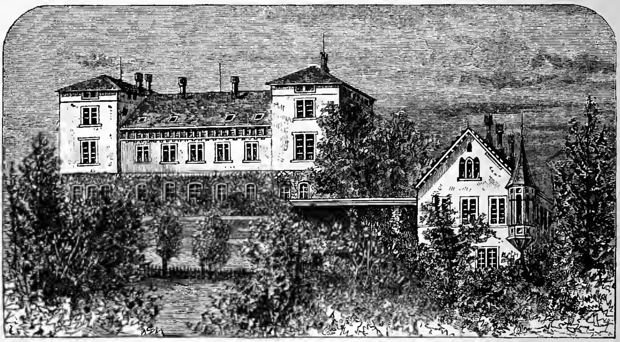
THE POMOLOGICAL AND HORTICULTURAL SCHOOL

IN REUTLINGEN, WÜRTTEMBERG.

This school was founded in 1860 by Dr. Edward Lucas, formerly Royal Garden Inspector and Director of the Horticultural School in Hohenheim. Up to 1880 it had educated over one thousand pupils, many of whom occupy important positions, and are materially aiding in elevating the science and practice

of pomology and horticulture in Germany. The sole aim of the school is to advance these sciences, and educate specialists. The buildings, besides apartments for four families, accommodate forty-five pupils.

The school-grounds comprise, in all, sixteen hectares, — nine in Reutlingen, and seven in Unter-Lennigen, — where there is a branch department of lower grade for poorer pupils, who study, mainly, hop, grapevine, and meadow culture. It will not be necessary to go into any detail in regard to studies, or division of time between theory and practice. It will be suffcient to note that the hours for instruction are in summer from five to seven, and in winter from six to eight, mornings, from eleven to twelve, noon, and from six to seven, evenings; the remainder of the time being devoted to out-door practice. The younger



THE POMOLOGICAL AND HORTICULTURAL SCHOOL IN REUTLINGEN, GERMANY.

students, who are studying horticulture, usually work one hour per day more than students in the higher departments. In the three-years course in fruit and garden culture, the entire cost to each student is five hundred and thirty marks for the first year, four hundred and ten for the second, and three hundred for the third; in the second and third years an allowance being made for labor. In the higher three-years course in pomology and garden construction, the entire cost for the first year is six hundred marks; in the second, five hundred; and in the third, four hundred; allowance being made for labor as above.

This is a school of higher grade than the farm-school in Hohenheim, but so similar in all the details of management, that any further description is unnecessary.

The decay of the system of apprenticeship has raised the question how skilled labor is to be provided in the future. This question is now agitating all countries having any industries to foster or extend. In our own country the more extended and varied use of machinery has caused the more rapid decay of the system, and if we except, perhaps, England, no country stands to-day in such urgent need of a remedy or substitute. In the early days in our own country, when our system of public education was still in its infancy, mental and manual education were much more intimately connected than at the present day. The industries of the country were still in a crude state; agriculture and a few only of the more necessary mechanic trades having any existence. These trades demanded but little artistic taste, and not the highest manual skill. The master became responsible, in an important sense, for the mental and moral well-being of the apprentice, besides teaching him the manual of his trade, with such knowledge of the theory and such experience as he was able to impart. By his attendance, for three or four months of each year during his apprenticeship, upon the district school, the mental culture of the apprentice was not entirely discontinued; and thus, by alternating between the school and the shop, his mental and manual education were never entirely divorced, but each in an important sense aided the other.

As time passed, a more marked separation between mental and manual education began to take place. The schools gradually improved. Better methods of teaching and a larger number of subjects were introduced, and a higher standard set, all demanding more time from the pupil. But quite as marked a change was going on in the industries. Increased demand led to competition, to the invention of special tools to cheapen production, to a greater subdivision of labor, and to the concentration of the individual upon a very narrow range of work. Thus the apprenticeship system for learning a trade in its old and best form has passed away, never to return. As it exists to-day it is an advantage to neither party. The apprentice can only learn a narrow specialty, so narrow, as a rule, that its only value to him is the meagre pittance which he can earn from day to day, but at the sacrifice of any further educational advantages; while the master finds it for his interest to pay for the skill he needs, rather than put into his carefully adjusted chain

of operations a weak and nearly useless link. In this way the school and the shop have become so widely separated, that they are no longer mutual helps, as in past times, in developing the highest capacity or the highest manhood. The student who enters the shop at fifteen for a three or four years' apprenticeship seldom returns to the school; and, on the other hand, the student who completes his high-school course at eighteen seldom willingly enters the shop as an apprentice, with the intention of becoming a skilled mechanic, and earning a livelihood by manual labor. His twelve or fourteen years of mental school-work, whether highly successful or not, have, through habit, if in no other way, unfitted him for all manual work, even if he has not in many ways been taught to despise such labor.

In England, says Professor Silvanus P. Thompson, in "Contemporary Review" for September, 1880, —

"Time was when, for the most part, the skilled artisan who was the master of his trade worked at home in his own house, assisted, it might be, by a few younger workmen or journeymen. Into his house and family he would receive one or two young lads to learn, during a seven-years' engagement, the art and mystery of his craft; the master himself working and teaching them his work, feeding and clothing them, and receiving from them in return the value of the services which, as they became more apt in their work, they were able to render. The advantages of thorough training by the continuous care of the master were unquestionably proven by the universal adoption of the system. The ancient guilds grew and acquired their legal status upon this usage as their very foundation, and a seven-years' apprenticeship formed the one necessary qualification for the possession of the right to exercise the following of any occupation or employment, art or craft, recognized among the handicrafts of the time. With the extension of trade and the wider use of machinery the number and power of the adult employed workmen increased, and with their increase of power came a jealousy, on the one hand, toward the masters; and, on the other, toward the apprentices, who were regarded as cheapening labor when employed in too great numbers. The conflict which arose between employer and employed gradually merged into one between capital and labor. By dint of strikes the workmen at last prevailed, and, in attempting to bring about a limitation in the amount of apprenticeship labor, brought about a result of quite another kind, and one far more disastrous than the evil sought to be remedied, — the destruction of all the best and most important features of apprenticeship."

On the Continent the same changes, though less rapidly, are taking place. There is less concentration, and the various trades are still largely in the hands of individuals and families,

and handed down to sons or others to whom they have been taught through the old system of apprenticeship. In Germany the young mechanic, in many instances, still finishes his education by two or three years of *journeymanship*, which enables him to gain further knowledge and experience in his trade, and see something of the world before settling down to his life's work. But the change is gradually taking place in all countries, and all are preparing to meet it through some form of education. England, as is well known, has, during the past twenty-five years, by the introduction of a general system of elementary education, including drawing, and through special technical schools and museums, revolutionized many of her industries, particularly those involving artistic taste in design as well as excellence in manufacture.

But in practical education in the mechanic arts, so far as I am aware, nothing has been done in England. In this direction France has long taken the lead, and has in the last few years awakened anew to the importance of the subject. The introduction of the mechanic art method of teaching, and the influence which this method is having in modifying the details of instruction in the various trade-schools, constitutes a new era in technical education in France.

It is well understood that Germany still produces skilled mechanics, especially wood and metal workers, many of whom find their way to England and this country. But this is not due to the introduction of any system of manual education in this direction. When the older polytechnic schools, such as those at Karlsruhe and Stuttgart, were established, shop instruction constituted a part of their educational scheme; but it soon fell into disuse for want of some plan by which alone success could have been made possible; and the result is that the influence of all the German polytechnic schools is opposed to such education by any method. Even the trade-school at Augsburg, which ranked for many years with that at Chalons-sur-Marne in France, both in its methods and aims, has for some reason been discontinued. But apprenticeship still prevails, in connection with a thorough public education in schools more or less adapted to the needs of classes of students. Drawing and the elements of the sciences are taught to a large extent in view of their uses in industrial pursuits; various special schools exist for the education of artisans, such as the excellent

Gewerbe-Schule of Stuttgart; but the manual skill must be gained in the practice of the trade, and not in the school.

Austria is quite as rapidly, if not more so than any other country, substituting systematic mechanic art instruction in place of the old apprenticeship system; and, if she shall adhere to her present course, it is not difficult to foresee that in a few years she will rank among the leading industrial countries of Europe.

In the foregoing I have included such schools as seemed to teach a special lesson in regard to the introduction of the manual element as part of a system of education. In addition to the remarks already made in connection with each, I wish simply to say in conclusion, that with but few pupils, so few that each can receive special instruction, a lack of system, or any system, may not be entirely fatal to some degree of success, any more than it would be to teach general, qualitative, and quantitative chemistry in the same laboratory; but no one would expect to get the best results. For large classes, on the other hand, special shops arranged for class-teaching become imperative. In the next place it is pretty generally admitted that, if only a general mechanic art training is desired, then shops arranged with this end in view are better than any manufacturing shops can be, whether considered on educational or economic grounds. Again, even in schools where manufacturing shops are part of the apparatus of instruction, it is becoming more apparent that a certain amount of preliminary or mechanic art training is necessary in order that the double aim of the shops, instruction and manufacturing, may both meet with reasonable success. While there may be special reasons, such as the expectations of the public, or the belief that no valuable teaching can be done except through manufacturing, why this department of instruction should demand greater opportunities for application in the school than other subjects or departments of engineering, I am persuaded that the manufacturing element will gradually diminish even in schools where it already exists, both on the grounds of economy, and because a mechanic art training will in general be found to better prepare the student to choose wisely, besides opening to him a broader career for the future.

We sometimes see a formal argument made to prove the obvious proposition that an educated man makes a better mechanic

than an uneducated one; and it is hence inferred that our public-school system, in many ways so admirable, and the result of so many years of labor and experience, is all that can be desired, and that any suggestion of a modification which may the better adapt it to the future needs of the large proportion whose education is finished even in the grammar schools, is in the nature of an attack upon the system. But this is by no means the case. The quality of the education may be of the very best; and yet the question may be asked, whether an education based mainly upon scholastic studies, with so much drawing and science as time will allow, is the best course for the largest number of pupils. It is sometimes thought that the reason why so many graduates of high schools seek positions as clerks, book-keepers, and other light forms of labor, is because these positions are thought more genteel than pursuits involving manual labor. This may be true to some extent; but I apprehend that quite as frequently the graduate asks himself, What can I do? what has my education fitted me to do? There is but one answer, and he acts accordingly as he ought; for, even if he wished to follow some trade or industrial pursuit needing special technical knowledge, he may not be able to devote the time and money necessary even if the conditions of apprenticeship were favorable. Suppose now that the same student had the opportunity during his school course, say till eighteen years of age, to go through a well-arranged series of mechanic art shops under competent instructors: what are the chances that upon graduation he would not enter upon that pursuit for which he felt himself best fitted, and which held out the best prospects, not only for the pressing present, but for the future? That a a course of education forms habits as well as tastes, is obvious; and it is unreasonable to expect that pupils educated almost exclusively through one set of closely allied subjects should show a partiality for pursuits with which these subjects have only the most remote, if any, connection.

American boys and girls are not peculiar in this respect. The same tendency is noted and complained of abroad, when, in fact, it ought to be expected. What, then, is to be done? Will any thing short of educating the hands and head together answer? It might if manufacturing establishments would take young men after they leave school, and educate them in the quickest and best way. But this we are not to expect so long as it is

hardly more for their interest to take them into the shop and teach them handicraft, than into the drawing-room to teach them drawing. In short, the time has come when if a young man wishes to follow a certain course he must so far qualify himself as to be of use to his employer, and thus to himself; and, as the State cannot afford not to educate its children, it cannot afford not to so educate them as to make them the most serviceable to the State as producers and citizens.

But how can this be done at the least expense, and with the least change in our present public-school system? Obviously by utilizing our present educational facilities to the fullest extent, and not by pulling down in the hopes of building something better upon the ruins. It is also obvious that cities need this change more than the country, where almost every child is daily accustomed to some kind of manual labor on the farm or in the shop.

In the city two courses are open,—either to build up an independent mechanic art school, or to attach a series of shops or laboratories to the high school. If the intention is to specialize this education, then an independent mechanic art school would best accomplish the purpose, and at the same time most probably more or less injure the high school by drawing away some of its pupils. If, on the other hand, it is thought that a proper manual element should enter into the education of all, then the shops would be attached to the high school, and serve to strengthen it by attracting students who now do not see any gain in the high-school course unless they have the college or some other particular end in view. Admitting that two three-hour lessons per week for the four years would be as much time as would be needed for shop instruction, then a series of eight shops arranged to teach twenty-five in a section would accommodate twelve hundred pupils. It is plain that only the laboratory method would make it possible to teach this large number of pupils, and one such series of shops would be ample for a good-sized city.

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INSTITUTE OF TECHNOLOGY,
BOSTON, Feb. 13, 1882.